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Thermophysical Properties of
High Temperature Solid Materials

VOLUME 2ND NONFERROUS ALLOYS

Part: Nonferrous Binary Alloys

Thermophysical Properties
Research Center, Purdue University
Y. S. MOULOUKIAN, Editor

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Thermophysical Properties
of High Temperature
Solid Materials

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Thermophysical Properties of High Temperature Solid Materials

VOLUME 2: NONFERROUS ALLOYS

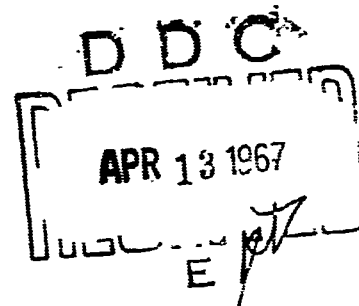
Part I: Nonferrous Binary Alloys

Thermophysical Properties Research Center
PURDUE UNIVERSITY

Y. S. Touloukian, EDITOR

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PREFACE

The phenomenal growth of science and technology since the early forties has brought about a universal appreciation of the fact that present limitations in many technical developments are often a direct result of the paucity of knowledge on the properties of materials. Engineering developments in the years ahead will be closely linked to the research that is done today to contribute to a better understanding of the properties of matter, of which thermophysical properties constitute a major segment.

With a realization of the seriousness of this situation, a great deal of research effort has been made in recent years on the thermophysical properties of materials with the result that the volume of research literature has increased many fold. In spite of this fact, it is generally agreed that the present level of research on thermophysical properties still falls substantially short of existing needs and anticipated future demands. However, what is even more disturbing is the fact that engineering groups across the nation are using no more than a fraction of the information already available, either because it is in a form not directly useful to them or, often, because its existence is not generally known.

To partially remedy this situation concerning the thermophysical properties of high temperature materials, the Materials Laboratory of the U.S. Air Force at Wright-Patterson Air Force Base sponsored a project in 1957 to bring together a large portion of the then available data in a single work for easy reference. From this compilation, performed by the Armour Research Foundation, a four-volume work entitled *Handbook of Thermophysical Properties of Solid Materials* emerged. It was first published in 1960 as WADC TR58-476; in 1961 it was issued as a hard-bound set by The Macmillan Company.

Because of the favorable reception given to this original work, the Materials Laboratory of the U.S. Air Force requested the Thermophysical Properties Research Center (TPRC), in 1964, to update and revise this reference work in order to increase its usefulness and to put it on a more current basis. The present six-volume work, entitled *Thermophysical Properties of High Temperature Solid Materials*, consists of nine books totaling more than 8,500 pages. It is the result of a two-year project by TPRC. This new encyclopedic reference work cannot be called a revised edition of the earlier publication since nearly every page has been changed through major additions, corrections, and re-evaluation. An effort was made to adhere to the basic format of the earlier work. However, the organization of the material and the index to materials have been completely redesigned for greater ease in locating the information desired.

Inevitably, not all of the properties covered have received the same degree of attention. The material on thermal radiative properties, thermal diffusivity, and specific heat has been totally revised and rewritten. Materials on the coefficient of thermal expansion and thermal conductivity have received major revisions, and those on electrical resistivity, density, and melting point have had moderate revisions. Finally, lesser revisions were made to data concerning vapor pressure and heats of transformation. The new information incorporated into the work covered research conducted primarily during the years 1957 to 1964, although some major references are included from 1965 and some from as far back as 1910.

In processing the large amount of new and old data incorporated in these volumes, it was necessary that some degree of selectivity be exercised both from the standpoint of the references cited and the data extracted from them. It is hoped, however, that no major source of information has been omitted. Whenever possible, an effort was made to suggest recommended values of the properties. In the plots, recommended values are indicated by curves. It should be clear, however, that the designation of "recommended values" in no way implies that a critical analysis has been performed in all cases, nor does it suggest that they repre-

sent definitive values. Because most of the materials covered are not well-defined engineering materials, and because there is often a great paucity of information, any critical evaluation of these data is most difficult—if not impossible.

With a full appreciation of these inherent difficulties it is nevertheless hoped that the present compendia will prove to be of great usefulness to engineers seeking information on thermophysical properties. In spite of the extreme care exercised in processing the data and proofing the manuscript, it is possible that some errors might have been inadvertently overlooked. Should any instance of such oversight be uncovered, the Editor would be most indebted if it is brought to his attention.

The fact that such an enormous undertaking could be accomplished in such a short time is attributable primarily to TPRC's unique resources in the area of thermophysical properties information. Grateful acknowledgment is made to the Electronic Properties Information Center for assistance in providing bibliographic searches on electrical resistivity and to the Air Force Materials Laboratory for general assistance in bibliographic information. Extensive personal inquiries were made to the authors of research papers and reports requesting clarification and original data. The enthusiastic response to these inquiries (in the majority of the cases) is also gratefully acknowledged. The Editor and the contributing staff wish to give a special note of thanks in acknowledging the valuable assistance and cooperation they received individually and collectively from TPRC's Scientific Documentation Division personnel and the supporting staff of graphics and technical typists without whose painstaking and skillful contributions this work would not have been possible.

This work was performed under Contract No. AF33(615)1642, sponsored by the Air Force Materials Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. The personnel directly affiliated with this program were Mr. D. A. Shunn, Chief, Materials Information Branch; Mr. E. Dugger, Technical Manager, Information Processing; and Mr. J. H. Charlesworth, engineer in charge of this project. Their understanding cooperation has contributed much to the success of the program.

It is sincerely hoped that *Thermophysical Properties of High Temperature Solid Materials* will constitute an even more valuable contribution to technology than its predecessor. This work should prove to be an invaluable source of information on an important group of properties of materials to every engineer, providing him with reliable information of a scope that would be impossible for any one individual to master. If we have been able to approach these goals, the results will be highly gratifying.

June 1966

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EXPLANATORY TEXT

I. SCOPE OF COVERAGE

Thermophysical Properties of High Temperature Solid Materials comprises six volumes. Volumes 2, 4, and 6 each consist of two parts because of the large amount of material covered. The general contents of the respective volumes are as follows:

Volume 1—Elements

Volume 2—Nonferrous Alloys

PART I—Nonferrous Binary Alloys

PART II—Nonferrous Multiple Alloys

Volume 3—Ferrous Alloys

Volume 4—Oxides and Their Solutions and Mixtures

PART I—Simple Oxygen Compounds and Their Mixtures

PART II—Solutions and Their Mixtures of Simple Oxygen Compounds, Including Glasses and Ceramic Materials

Volume 5—Nonoxides and Their Solutions and Mixtures, Including Miscellaneous Ceramic Materials

Volume 6—Intermetallics, Cermets, Polymers, and Composite Systems

PART I—Intermetallics

PART II—Cermets, Polymers, and Composite Systems

The specific properties covered in each volume are:

1. Density (ρ)
2. Melting Point (M. P.)
3. Heat of Fusion (Δh_f)
4. Heat of Vaporization (Δh_v)
5. Heat of Sublimation (Δh_s)
6. Electrical Resistivity (ρ)
7. Specific Heat at Constant Pressure (c_p)
8. Thermal Conductivity (k)
9. Thermal Diffusivity (α)
10. Thermal Linear Expansion ($\Delta L/L$)
11. Thermal Radiative Properties:
Absorptance (α), Emittance (ϵ), Reflectance (ρ), and Transmittance (τ)
12. Vapor Pressure (p)

Generally, only materials with melting points above 800°K (approximately 1000°F) are included, except for materials within the categories of polymers, plastics, and composites. A detailed discussion of the material classification procedure is presented in the following section. A Material Index for the entire work is included at the end of each volume.

II. TPRC CLASSIFICATION OF MATERIALS

Materials are classified into the eight categories listed below. Whenever applicable, the compositions are reported in weight percent of the constituents. For purposes of material classification TPRC considers the following elements as nonmetallic: H, He, C, N, O, F, Ne, P, S, Cl, A, Br, Kr, I, Xe, At, and Rn.

1. *Elements*: For the purpose of classification an element is specified as follows:
 - A. For metallic elements, the limit of impurities is <0.20 percent for each foreign constituent and <0.50 percent total impurities.
 - B. For nonmetallic elements (i.e., carbon including graphite and diamond), the limit of impurities is ≤ 2.0 percent for each foreign constituent and ≤ 5.0 percent total impurities.
2. *Nonferrous Alloys*: This category is for alloys in which the major constituent is other than iron. For the purpose of classification, nonferrous alloys are specified as follows:
 - A. Nonferrous Binary Alloys: The sum of the binary constituents is ≥ 99.50 percent and other constituents ≤ 0.20 percent each.
 - B. Nonferrous Multiple Alloys: The sum of the first two constituents is <99.50 percent and/or any other constituent >0.20 percent. Alternatively, the major constituent is ≤ 99.50 percent and each of the other constituents <0.20 percent (or not given).
3. *Ferrous Alloys*: This category is for alloys in which iron is greater than or equal to any other constituent. For the purpose of classification, ferrous alloys are specified as follows:
 - A. Carbon Steels: Carbon ≤ 2.0 percent and carbon \geq any other alloying constituent.
 - a. Group I: Every other alloying constituent is ≤ 0.20 percent except for Mn, P, S, Si, which may be ≤ 0.60 percent each.
 - b. Group II: At least one other alloying constituent >0.20 percent and/or any of Mn, P, S, Si >0.60 percent.
 - B. Cast Irons: Carbon >2.0 percent and carbon \geq any other alloying constituent.
 - a. Group I: Every other alloying constituent ≤ 0.20 percent except for Mn, P, S, Si, which may be ≤ 0.60 percent each.
 - b. Group II: At least one other alloying constituent >0.20 percent and/or any of Mn, P, S, Si >0.60 percent.
 - C. Alloy Steels (including alloy cast iron): The major alloying constituent is other than carbon.
 - a. Group I: Every other alloying constituent ≤ 0.20 percent except for Mn, P, S, Si, which may be ≤ 0.60 percent each, and C ≤ 2.0 percent.*
 - b. Group II: At least one other alloying constituent >0.20 percent and/or any of Mn, P, S, Si >0.60 percent.*
4. *Nonmetallic Compounds and Their Mixtures and Solutions*: Ceramic materials such as oxides, bromides, carbides, carbonates, nitrides, silicates, etc., are included in this category. For the purpose of classification, they are specified as follows:
 - A. For simple compounds and their solutions, the limit of impurities is ≤ 2.0 percent for each foreign constituent and ≤ 5.0 percent total impurities.

* Exception is made when Mn, P, S, or Si is the major alloying constituent. For instance, in the case of Fe + Mn + 2X₁ alloys the specifications corresponding to Groups I and II would be as follows:

a. Group I: Every other alloying constituent ≤ 0.20 percent except for P, S, Si, which may be ≤ 0.60 percent each, and C ≤ 2.0 percent.

b. Group II: At least one other alloying constituent >0.20 percent and/or any of P, S, Si >0.60 percent.

In the above example, Mn has a higher weight percentage than any of P, S, or Si but does not necessarily have a weight percentage higher than 0.60 percent. Thus, the limits of Mn percentage may be written:

Fe \geq Mn $>$ P, S, Si and any other alloying constituent and Mn ≥ 0.20 .

The same guideline is applied to ferrous alloys containing P, S, or Si as major alloying constituents.

B. For mixtures of simple compounds and their solutions, the major constituent is <95.0 percent, or any other constituent is >2.0 percent.

5. *Intermetallics*: An intermetallic is a metal-metal compound formed by metallic elements in a fixed simple atomic ratio. For the purpose of classification, specifications are the same as those for Class 4.
6. *Cermets*: Cermets are ceramic materials such as carbides, oxides, etc., fused with or bonded by one or more pure metals. However, there are also metal-metal cermets, metal-intermetallic cermets, etc., which are also included in this category.
7. *Polymers*: Polymers are chemical compounds or mixtures of compounds formed by polymerization and consisting essentially of repeating molecular structural units.
8. *Composite Systems*: A composite system may consist of materials in combination, with clearly defined boundaries existing between components of the system, or a homogeneous material having a distinct configuration.

For the reader's convenience, the classification scheme for Classes 1 through 4, described above, is summarized in the following table.

SUMMARY TABLE OF TPRC CLASSIFICATION OF MATERIALS

| Classification | | | Limits of Composition (weight percent) | | | | |
|---|---|-------------------------------|--|--------------|-------------|------------------------------|-------------|
| | | | X_1 | $X_1 + X_2$ | X_2 | X_3 | |
| 1. ELEMENTS | A. METALLIC | _____ | >99.50 | -- | <0.20 | <0.20 | |
| | B. NONMETALLIC | _____ | ≥ 95.0 | -- | ≤ 2.0 | ≤ 2.0 | |
| 2. NONFERROUS ALLOYS ($X_1 > \text{Fe}$) | A. BINARY ALLOYS | _____ | -- | ≥ 99.50 | ≥ 0.20 | ≤ 0.20 | |
| | | _____ | -- | ≥ 99.50 | > 0.20 | > 0.20 | |
| | B. MULTIPLE ALLOYS | _____ | -- | <99.50 | ≥ 0.20 | ≤ 0.20 | |
| | | _____ | -- | <99.50 | > 0.20 | > 0.20 | |
| | | _____ | ≤ 99.50 | -- | < 0.20 | < 0.20 | |
| 3. FERROUS ALLOYS ($X_1 = \text{Fe} \geq X_2$) | A. CARBON STEELS | GROUP I | Fe | $C \leq 2.0$ | ≤ 0.20 | ≤ 0.60 | |
| | | | Fe | $C \leq 2.0$ | ≤ 0.20 | > 0.60 | |
| | | GROUP II | Fe | $C \leq 2.0$ | > 0.20 | ≤ 0.60 | |
| | | | Fe | $C \leq 2.0$ | > 0.20 | > 0.60 | |
| | B. CAST IRONS | GROUP I | Fe | $C > 2.0$ | ≤ 0.20 | ≤ 0.60 | |
| | | | Fe | $C > 2.0$ | ≤ 0.20 | > 0.60 | |
| | | GROUP II | Fe | $C > 2.0$ | > 0.20 | ≤ 0.60 | |
| | | | Fe | $C > 2.0$ | > 0.20 | > 0.60 | |
| | | C. ALLOYS [*] STEELS | GROUP I | Fe | $\neq C$ | ≤ 0.20 and $C \leq 2.0$ | ≤ 0.50 |
| | | | | Fe | $\neq C$ | ≤ 0.20 | > 0.60 |
| | GROUP II | | Fe | $\neq C$ | > 0.20 | ≤ 0.60 | |
| | | | Fe | $\neq C$ | > 0.20 | > 0.60 | |
| | 4. NONMETALLIC COMPOUNDS AND THEIR MIXTURES AND SOLUTIONS | | | | | | |
| | | | | X_1 | X_2 | | |
| A. SIMPLE COMPOUNDS AND THEIR SOLUTIONS | | | _____ | ≥ 95.0 | ≤ 2.0 | | |
| B. MIXTURES OF SIMPLE COMPOUNDS AND THEIR SOLUTIONS | | | _____ | < 95.0 | ≤ 2.0 | | |
| | | | | ≥ 95.0 | > 2.0 | | |
| | | | | < 95.0 | > 2.0 | | |

NOMENCLATURE:

X_1 = Major Constituent

X_2 = Second Highest Constituent

X_3 = Third Highest Constituent

Where: $X_1 \geq X_2 \geq X_3 \geq X_4 \geq \dots$

* In case Mn, P, S, or Si represents X_2 this particular element is dropped from the last column.

III. PRESENTATION OF DATA

Each of the six volumes consists of seven sections arranged in the following order:

1. Preface
2. Table of Contents
3. Explanatory Text
4. Conversion Factors
5. Body of Data
6. References
7. Material Index.

In the following paragraphs a detailed description of Sections 5, 6, and 7 is given. The contents of the first four sections are self-explanatory.

BODY OF DATA

Data on each material are presented in graphical or tabular form for selected sets of measurements, and are accompanied by a Reference Information Table with corresponding specifications and remarks. The first five properties listed in Section I of this Explanatory Text are considered as *point values* and are grouped together in a single table in the same manner as the graphs for the other remaining properties. Furthermore, for a given material group, where several properties are reported, data are arranged in accordance with the order of the property list given in Section I of this text.

Graphic Presentation

Data extracted from various references on a given material and property are shown on a single graph by means of distinct plotting symbols, which are identified in the Reference Information Table on the page following the graph. Each set of symbols indicates the data of a given investigator, but does not necessarily imply actual measured points. In numerous instances authors present only smoothed values, either in graphical or tabular form, and it is frequently impossible to distinguish interpolated or smoothed values from actual observed data.

In reporting data on thermal linear expansion, investigators sometimes give a single average value of this property for a considerable temperature range. In such instances it is assumed that a linear relationship is implied. All data on thermal linear expansion were reduced to a datum of 293°K (20°C); i.e., $(\Delta L/L) = 0$ at 293°K (20°C). This point is identified by a cross (+) on each graph.

The definition of $(\Delta L/L)$ used in this work is

$$(\Delta L/L) = \frac{L_T - L_{293}}{L_{293}} \times 100$$

where L_T = length of specimen at temperature T .

L_{293} = length of specimen at 293°K (20°C).

To compute the "coefficient" of thermal linear expansion β from 293°K to any temperature T , the following relation may be used.*

$$\beta = \frac{1}{100(T - 293)} \frac{\Delta L}{L}, \text{ in } K^{-1}$$

* It is necessary to divide the right-hand side of this equation by 100 because the graphical presentation of $(\Delta L/L)$ is in percent expansion from 293°K.

In some instances the coefficient of thermal linear expansion is reported in tabular form.

Curves drawn through the plotted points are the "most probable" curves based on the data shown. As additional information becomes available in the future, these recommendations may well be modified.

Point Value Table

Data extracted from various references are identified by distinct symbols in the same manner as data points on a graph. "Most probable" values are given either at the top of the table or are indicated in a footnote. These selections are usually made solely on the basis of the data presented. Sometimes these point values are also reported as a function of temperature or composition, in which case they are shown in graphical form and placed immediately following the tabular values.

Reference Information Table

A table giving the reference information associated with each set of data obtained in the graph immediately follows the graph. The table contains the following information:

1. **Symbol** The plotting symbols are identical with and correspond to those used in the graph.
2. **Reference.** References are identified by hyphenated numbers which serve to locate the bibliographic citation in the section of References at the end of each volume. The initial two digits indicate the year of publication and the last digits identify the specific reference within the given year. In those instances where a reference does not carry a date, the letter symbol ND is used in place of the year of publication. Undated references are listed at the end of the list of References.
3. **Temperature Range.** Range covered by the data in a given paper or report.
4. **Reported Error.** The author's estimated accuracy (or precision).
5. **Sample Specification.** This column contains all pertinent available information about the test sample. This information consists of the following:
 - a. Commercial trade name, chemical formula, etc., followed by manufacturer's name, if it is necessary for correct identification.
 - b. Composition of the sample, expressed in weight percent. Unless otherwise stated, the percent sign is omitted.
 - c. Physical characteristics of the material, such as a single crystal, polycrystalline, density, crystal structures, etc.
 - d. Specimen designation by the author is given in brackets at the end of the citation.
6. **Remarks.** This column contains information on:
 - a. Special process used in fabrication of the sample, such as being sintered, chill-cast, etc.
 - b. Sample history, such as cold-worked, hot-pressed, annealed, etc.
 - c. Conditions under which the specimen was investigated, environment, etc.
 - d. Other pertinent remarks.

REFERENCES

The section on Reference gives complete bibliographic citations for all the references from which data were extracted. They are arranged chronologically by year of publication, and in arbitrary sequence within any given year.

For the preparation of the references, the following order and convention is used.

Periodicals

1. **Author(s) name:** Last name first, followed by initials.
2. **Journal name:** Standard TPRC journal name abbreviations are used.
3. **Series, volume, and number.**

- a. If the series is represented by a letter, it is underlined together with the volume number.
- b. If the series is represented by a number, then only the numeral representing the volume is underlined.
- c. The numeral for the issue number is shown in parentheses.
4. Pages: Indicate the beginning and ending pages.

Reports

1. Author(s) name is given in the same form as for periodicals.
2. The name of the responsible organization, if any.
3. The name of sponsor.
4. Report, bulletin, or circular designation.
5. Number.
6. Part.
7. Pages (same as for periodicals).
8. AD and PB numbers or equivalents.

Books

The bibliographic citation for books lists: author(s), title, volume, edition, publisher, and page(s).

In general, private communications are not listed as references. However, if TPRC did obtain additional substantive information from an author through private communication, and if this information was used, the remark "additional data obtained from author(s)" is added at the end of the reference citation.

MATERIAL INDEX

The Material Index lists all the materials included in this work by their proper trade or commercial names arranged in alphabetical order and, for materials designated by number codes, the listing is in increasing numerical order. Location of information on a particular property for a particular material is specified by the volume number and page numbers indicated within the appropriate property column of the index. The page number always indicates the starting page of the graphs or point value tables. Chemical formulas are given in parentheses following the proper names of materials which can be chemically identified. However, for materials within a general group, e.g., different oxides of cerium, the entries are only by chemical formulas listed under the material group designation, such as "cerium oxides." Whenever applicable, an effort is made to list commercial materials under their several accepted names. In the case of broad classes of materials, such as steels, glasses, etc., the materials are listed under their common names as well as under the heading of their general class when the designation is merely a letter and number code.

Simple inorganic compounds (e.g., aluminum oxide, tantalum boride) are named according to the convention given in the *Handbook of Chemistry and Physics* (The Chemical Rubber Co., 45th edition, 1964, and—if not available there—the 43rd edition, 1962). Other inorganic compounds are generally named in accordance with the convention given in the *Chemical Abstracts* by giving the more electropositive part of the name first and the more electronegative part second. For nonferrous and ferrous alloys, only the first two components are listed and ΣX_i is added to designate multiple alloys. An exception is made, however, for chromium-nickel and nickel-chromium ferrous alloys, in which cases, all three major constituents are listed. For other inorganic compounds and their mixtures and solutions, all components with weight percent greater than . percent are listed. Finally, for cermets, the name of the ceramic part is given first and the metal part second, each in their respective alphabetical order regardless of their weight percentages, with the exception of beryllium cermet (e.g., Beryllium YB-9052), in which case the name of the metal part is given first.

CONVERSION FACTORS

NOTE: In preparing the conversion factors, the following basic definitions were used:

$$1 \text{ in.} = 2.54 \text{ cm}^*$$

$$1 \text{ lb.} = 453.59237 \text{ g}^*$$

$$1 \text{ cal}_{\text{Th}} = 4.184 \text{ (exactly) Joule}^*$$

$$1 \text{ cal}_{\text{IT}} = 4.1868 \text{ (exactly) Joule}^*$$

$$1 \text{ Btu}_{\text{IT}} \text{ lb}^{-1} \text{ F}^{-1} = 1 \text{ cal}_{\text{IT}} \text{ g}^{-1} \text{ C}^{-1} \dagger$$

The subscripts "Th" and "IT" denote "Thermochemical" and "International Steam Table" units, respectively.

* NBS Technical News Bulletin, 47(10), 1963.

† Mueller, E. F., and Rossini, F. D., *Am. J. Physics*, 12(1), 4, 1944.

CONVERSION FACTORS FOR UNITS OF DENSITY

| MULTIPLY by appropriate factor to OBTAIN | g cm ⁻³ | g in. ⁻³ | kg m ⁻³ | kg ft ⁻³ | lb in. ⁻³ | lb ft ⁻³ |
|---|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| g cm ⁻³ | 1 | 1.63872 x 10 ⁻¹ | 1.0 x 10 ³ | 2.83170 x 10 ⁻¹ | 3.61275 x 10 ⁻² | 6.24283 x 10 ⁻³ |
| g in. ⁻³ | 6.10234 x 10 ⁻² | 1 | 6.10234 x 10 ⁻¹ | 1.72800 | 2.20462 x 10 ⁻³ | 3.80559 |
| kg m ⁻³ | 1.0 x 10 ³ | 1.63872 x 10 ⁻² | 1 | 2.83170 x 10 ⁻¹ | 3.61275 x 10 ⁻⁴ | 6.24283 x 10 ⁻² |
| kg ft ⁻³ | 3.51446 x 10 ⁻² | 5.78704 x 10 ⁻¹ | 3.51446 x 10 ⁻¹ | 1 | 1.27582 x 10 ⁻¹ | 2.20462 |
| lb in. ⁻³ | 2.76797 x 10 ⁻¹ | 4.53592 x 10 ⁻¹ | 2.76797 x 10 ⁻¹ | 7.83808 x 10 ⁻² | 1 | 1.72800 x 10 ⁻¹ |
| lb ft ⁻³ | 1.60184 x 10 ⁻¹ | 2.62496 x 10 ⁻¹ | 1.60184 x 10 ⁻¹ | 4.53592 x 10 ⁻¹ | 5.78704 x 10 ⁻⁴ | 1 |

CONVERSION FACTORS FOR UNITS OF LATENT HEAT

| MULTIPLY by appropriate factor to OBTAIN | $\text{cal}_{Th} \text{ g}^{-1}$ | $\text{cal}_{IT} \text{ g}^{-1}$ | W sec g^{-1} | $\text{J}_{Int} \text{ g}^{-1}$ | $\text{Btu}_{Th} \text{ lb}^{-1}$ | $\text{Btu}_{IT} \text{ lb}^{-1}$ |
|---|----------------------------------|----------------------------------|-----------------------|---------------------------------|-----------------------------------|-----------------------------------|
| $\text{cal}_{Th} \text{ g}^{-1}$ | 1 | 9.99331×10^{-1} | 4.184 | 4.18331 | 1.8 | 1.79880 |
| $\text{cal}_{IT} \text{ g}^{-1}$ | 1.00067 | 1 | 4.1868 | 4.18611 | 1.80120 | 1.8 |
| W sec g^{-1} | 2.39006×10^{-1} | 2.38846×10^{-1} | 1 | 9.99835×10^{-1} | 4.30210×10^{-1} | 4.29923×10^{-1} |
| $\text{J}_{Int} \text{ g}^{-1}$ | 2.39045×10^{-1} | 2.38885×10^{-1} | 1.00017 | 1 | 4.30281×10^{-1} | 4.29984×10^{-1} |
| $\text{Btu}_{Th} \text{ lb}^{-1}$ | 5.55556×10^{-1} | 5.55184×10^{-1} | 2.32444 | 2.32406 | 1 | 9.99331×10^{-1} |
| $\text{Btu}_{IT} \text{ lb}^{-1}$ | 5.55927×10^{-1} | 5.55556×10^{-1} | 2.326 | 2.32562 | 1.00067 | 1 |

CONVERSION FACTORS FOR UNITS OF SPECIFIC HEAT

| MULTIPLY by appropriate factor to OBTAIN | $\text{cal}_{\text{Th}} \text{g}^{-1} \text{C}^{-1}$ | $\text{cal}_{\text{IT}} \text{g}^{-1} \text{C}^{-1}$ | $\text{W sec g}^{-1} \text{K}^{-1}$ | $\text{J}_{\text{Int}} \text{g}^{-1} \text{K}^{-1}$ | $\text{Btu}_{\text{Th}} \text{lb}^{-1} \text{F}^{-1}$ | $\text{Btu}_{\text{IT}} \text{lb}^{-1} \text{F}^{-1}$ |
|---|--|--|-------------------------------------|---|---|---|
| $\text{cal}_{\text{Th}} \text{g}^{-1} \text{C}^{-1}$ | 1 | 0.99331×10^{-1} | 4.184 | 4.18681 | 1 | 9.99331×10^{-1} |
| $\text{cal}_{\text{IT}} \text{g}^{-1} \text{C}^{-1}$ | 1.00067 | 1 | 4.1868 | 4.18611 | 1.00067 | 1 |
| $\text{W sec g}^{-1} \text{K}^{-1}$ | 2.390006×10^{-1} | 2.38846×10^{-1} | 1 | 9.99835×10^{-1} | 2.39000×10^{-1} | 2.38846×10^{-1} |
| $\text{J}_{\text{Int}} \text{g}^{-1} \text{K}^{-1}$ | 2.39045×10^{-1} | 2.38885×10^{-1} | 1.00017 | 1 | 2.39045×10^{-1} | 2.38885×10^{-1} |
| $\text{Btu}_{\text{Th}} \text{lb}^{-1} \text{F}^{-1}$ | 1 | 9.99331×10^{-1} | 4.184 | 4.18631 | 1 | 9.99331×10^{-1} |
| $\text{Btu}_{\text{IT}} \text{lb}^{-1} \text{F}^{-1}$ | 1.00067 | 1 | 4.1868 | 4.18611 | 1.00067 | 1 |

Note: To convert quantities per "gram" to "mol" basis multiply conversion factor by the molecular weight M.

CONVERSION FACTORS FOR UNITS OF THERMAL CONDUCTIVITY

| MULTIPLY by appropriate factor to OBTAIN | $Btu_{IT} \cdot hr^{-1} \cdot ft^{-2} \cdot F^{-1}$ | $Btu_{IT} \cdot in. \cdot hr^{-1} \cdot ft^{-2} \cdot F^{-1}$ | $cal_{IT} \cdot sec^{-1} \cdot cm^{-1} \cdot C^{-1}$ | $cal_{TH} \cdot sec^{-1} \cdot cm^{-1} \cdot C^{-1}$ | $kcal_{TH} \cdot hr^{-1} \cdot m^{-1} \cdot C^{-1}$ | $W \cdot cm^{-1} \cdot K^{-1}$ |
|---|---|---|--|--|---|--------------------------------|
| $Btu_{IT} \cdot hr^{-1} \cdot ft^{-2} \cdot F^{-1}$ | 1 | 1.2×10 | 4.13379×10^{-3} | 4.13006×10^{-3} | 1.48016 | 1.73072×10^{-2} |
| $Btu_{IT} \cdot in. \cdot hr^{-1} \cdot ft^{-2} \cdot F^{-1}$ | 8.33333×10^{-2} | 1 | 3.44482×10^{-4} | 3.44713×10^{-4} | 1.24097×10^{-1} | 1.44228×10^{-2} |
| $cal_{IT} \cdot sec^{-1} \cdot cm^{-1} \cdot C^{-1}$ | 2.41909×10^3 | 2.90201×10^3 | 1 | 1.00007 | 3.60241×10^2 | 4.1808 |
| $cal_{TH} \cdot sec^{-1} \cdot cm^{-1} \cdot C^{-1}$ | 2.41747×10^3 | 2.90096×10^3 | 9.99391×10^{-4} | 1 | 3.6×10^2 | 4.184 |
| $kcal_{TH} \cdot hr^{-1} \cdot m^{-1} \cdot C^{-1}$ | 6.71630×10^{-1} | 8.05824 | 2.77592×10^{-3} | 2.77778×10^{-3} | 1 | 1.16223×10^{-1} |
| $W \cdot cm^{-1} \cdot K^{-1}$ | 3.77789×10 | 6.93347×10^3 | 2.38846×10^{-1} | 2.39000×10^{-1} | 8.30421×10 | 1 |

CONVERSION FACTORS FOR UNITS OF THERMAL DIFFUSIVITY

| MULTIPLY by appropriate factor to OBTAIN | $\text{cm}^2/\text{sec}^{-1}$ | $\text{cm}^2/\text{hr}^{-1}$ | $\text{m}^2/\text{hr}^{-1}$ | $\text{in.}^2/\text{sec}^{-1}$ | $\text{ft}^2/\text{sec}^{-1}$ | $\text{ft}^2/\text{hr}^{-1}$ |
|---|-------------------------------|------------------------------|-----------------------------|--------------------------------|-------------------------------|------------------------------|
| $\text{cm}^2/\text{sec}^{-1}$ | 1 | 3.60×10^3 | 3.60×10^{-1} | 1.550×10^{-1} | 1.07639×10^{-6} | 3.87631 |
| $\text{cm}^2/\text{hr}^{-1}$ | 2.77778×10^{-4} | 1 | 1.0×10^{-1} | 4.30566×10^{-1} | 2.98909×10^{-1} | 1.07639×10^{-3} |
| $\text{m}^2/\text{hr}^{-1}$ | 2.77778 | 1.0×10^4 | 1 | 4.30566 | 9.98909×10^{-3} | 1.07639×10 |
| $\text{in.}^2/\text{sec}^{-1}$ | 3.45160 | 9.02269×10^4 | 9.02269 | 1 | 9.94444×10^{-1} | 3.50×10 |
| $\text{ft}^2/\text{sec}^{-1}$ | 9.29030×10^1 | 3.34461×10^6 | 9.34461×10^2 | 1.440×10^2 | 1 | 9.00×10^3 |
| $\text{ft}^2/\text{hr}^{-1}$ | 9.68064×10^{-1} | 9.20030×10^3 | 9.20030×10^{-3} | 4.0×10^{-1} | 2.77778×10^{-4} | 1 |

CONVERSION FACTORS FOR UNITS OF VAPOR PRESSURE

| MULTIPLY by appropriate factor to OBTAIN → | dyne cm ⁻² | atm | kg cm ⁻² | mm Hg | in. Hg | lb in. ⁻² |
|---|-----------------------|--------------------------|--------------------------|-------------------------|-------------------------|--------------------------|
| dyne cm ⁻² | 1 | 9.8690×10^{-1} | 1.01970×10^{-6} | 7.5010×10^{-4} | 2.530×10^{-5} | 1.45040×10^{-5} |
| atm | 1.01339×10^6 | 1 | 1.03320 | 7.60×10^2 | 2.9920 x 10 | 1.46960×10 |
| kg cm ⁻² | 9.8070×10^5 | 9.6780×10^{-1} | 1 | 7.3560×10^2 | 2.8960×10 | 1.42230×10 |
| mm Hg | 1.33320×10^3 | 1.31580×10^{-3} | 1.35950×10^{-3} | 1 | 3.9370×10^{-2} | 1.93370×10^{-2} |
| in. Hg | 3.3860×10^4 | 3.3420×10^{-2} | 3.4530×10^{-2} | 2.540×10 | 1 | 4.9120×10^{-1} |
| lb in. ⁻² | 6.89470×10^4 | 6.80460×10^{-2} | 7.0310×10^{-2} | 5.1710×10 | 2.0360 | 1 |

BODY OF DATA

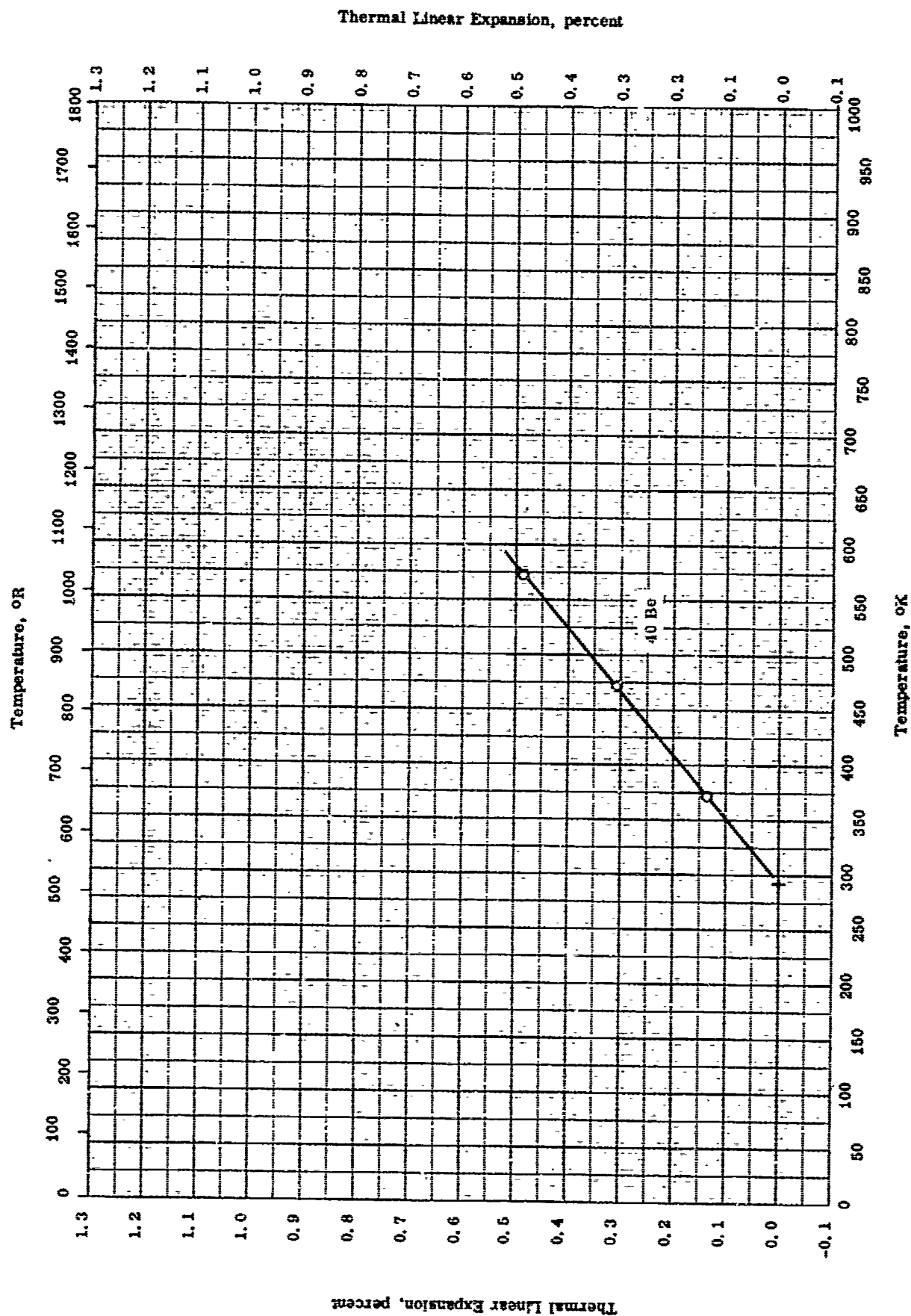
NONFERROUS ALLOYS

PART I

NONFERROUS BINARY ALLOYS

(Sum of the binary constituents ≥ 99.50 percent
and other constituents ≤ 0.20 percent each)

TPRC



TPRC

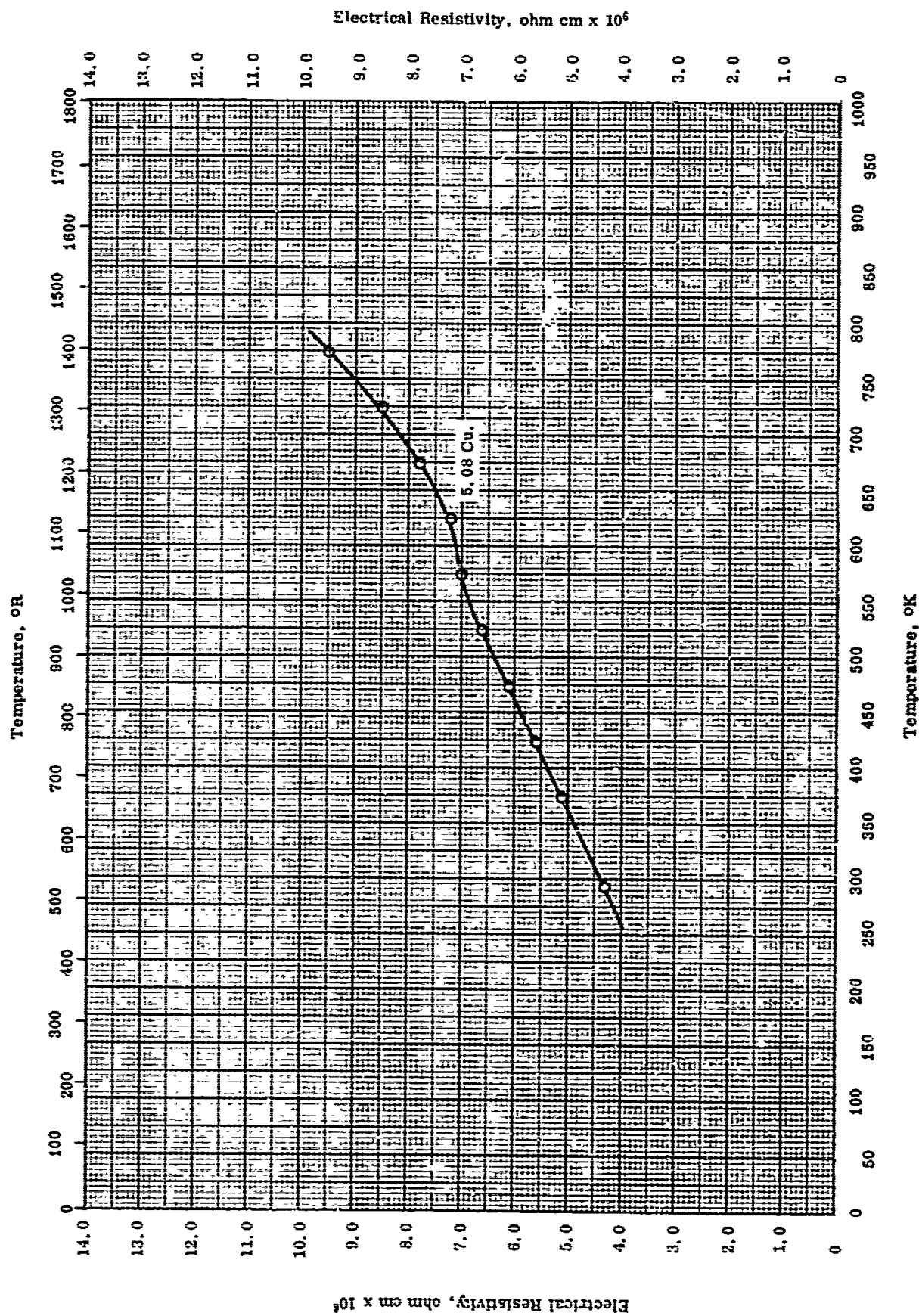
Thermal Linear Expansion -- ALUMINUM + BERYLLIUM

THERMAL LINEAR EXPANSION --- ALUMINUM + BERYLLIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------------|---|
| O | 52-19 | 293-573 | | 60 Al, 40 Be, and trace Ag. | Cast at 2300 F, heat treated at 1025 F for 24 hrs, hot forged annealed at 1025 F for 4 hrs, water quenched, and cold worked from 3/4 in. to 5/8 in. dia. |

TPRC

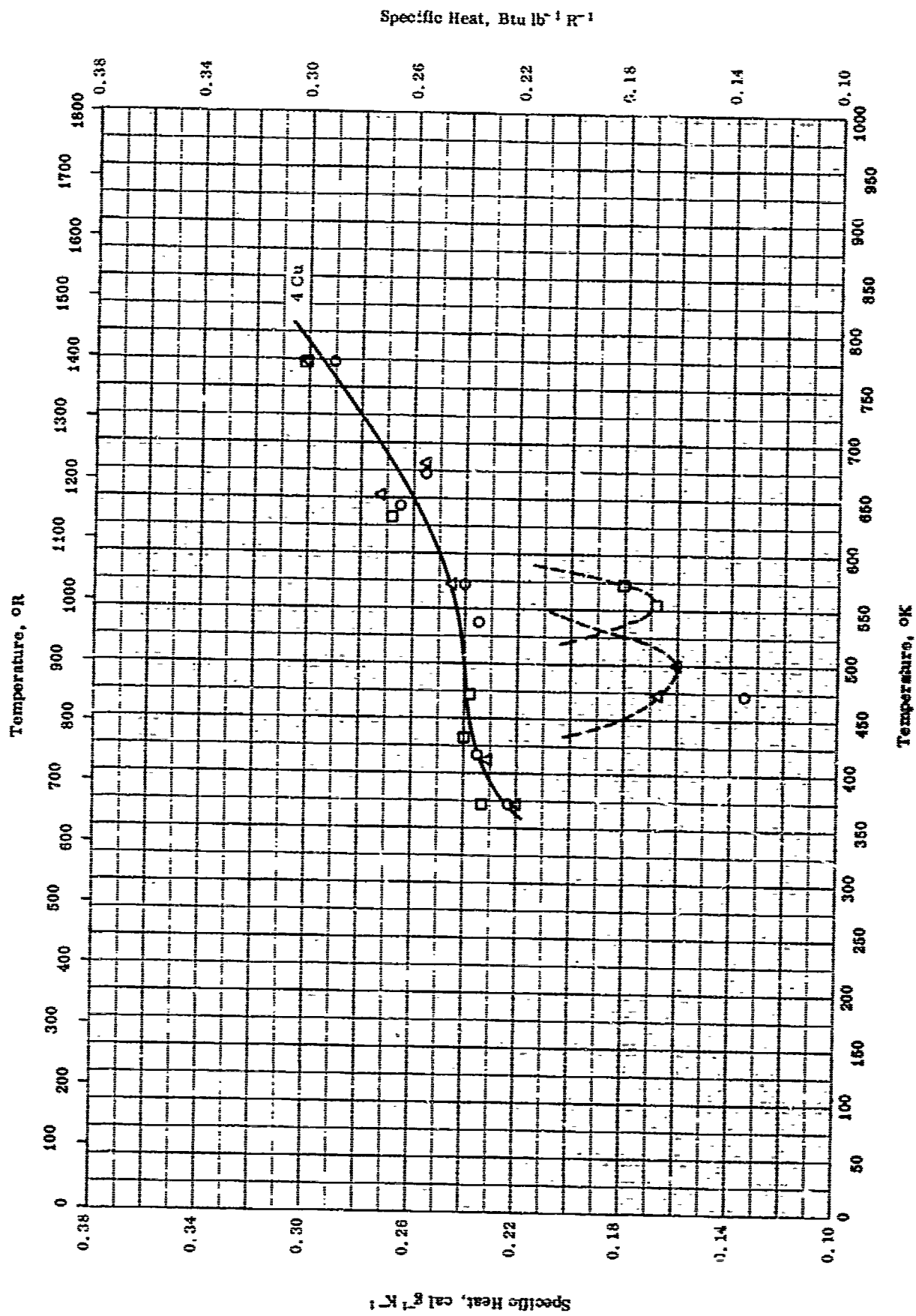


ELECTRICAL RESISTIVITY -- ALUMINUM + COPPER

ELECTRICAL RESISTIVITY -- ALUMINUM + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---|
| O | 48-1 | 293-1073 | | 5.08 Cu, 0.15 Fe, 0.05 each Si and Zn, 0.02 Ti, and traces of Mg, Mn. | Cast; heated 6 hrs at 970 F and water quenched. |



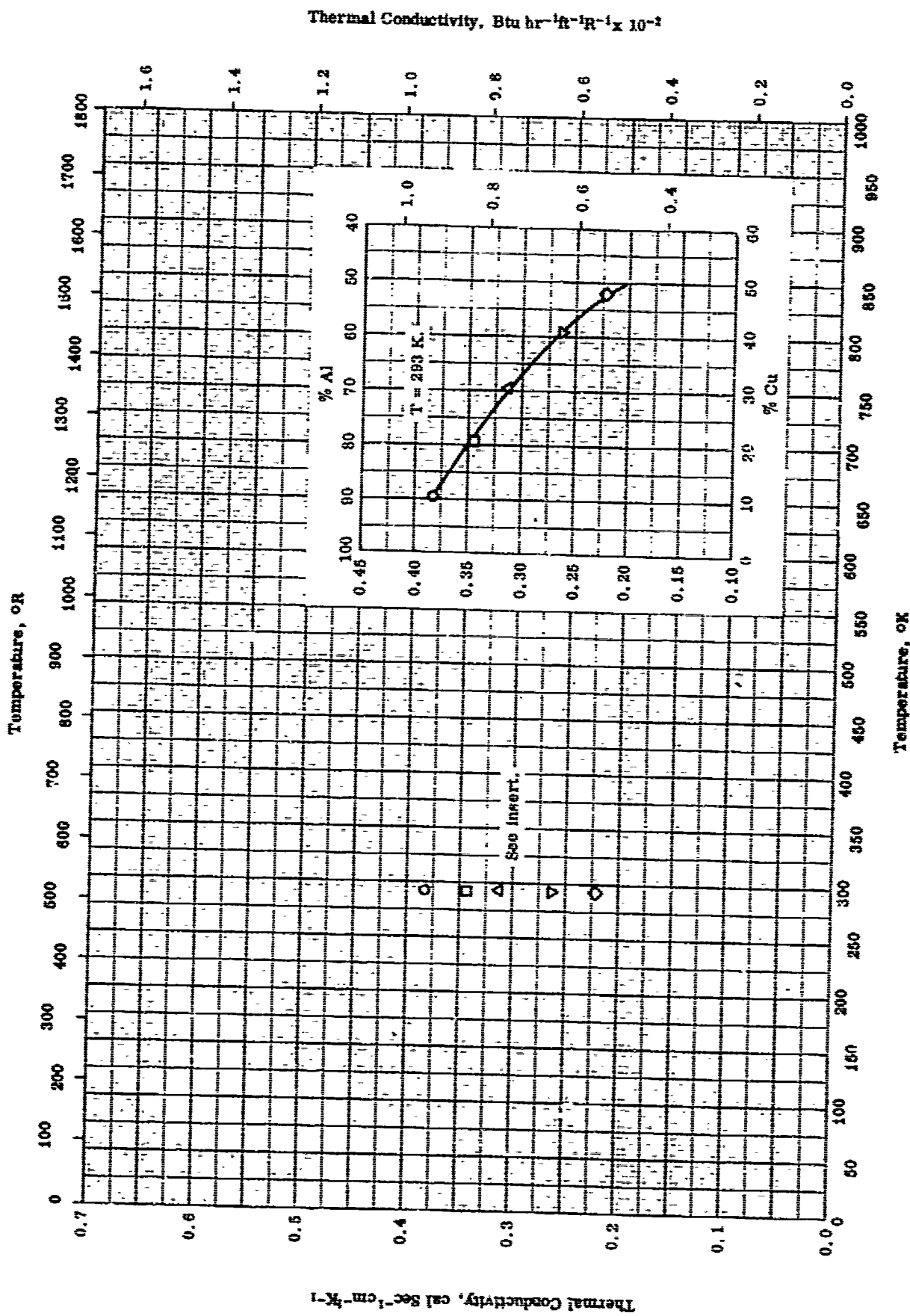
SPECIFIC HEAT -- ALUMINUM + COPPER

SPECIFIC HEAT -- ALUMINUM + COPPER

REFERENCE INFORMATION

| Sym Ecl | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 55-11 | 373-773 | | 4 Cu. and 0.05 Sn. | Forged, solution treated at 530 C, and quenched. |
| □ | 55-11 | 373-773 | | 4 Cu | Same as above. |
| △ | 55-11 | 373-773 | | 4 Cu and 0.02 Sn. | Same as above. |

TPRC



THERMAL CONDUCTIVITY -- ALUMINUM + COPPER

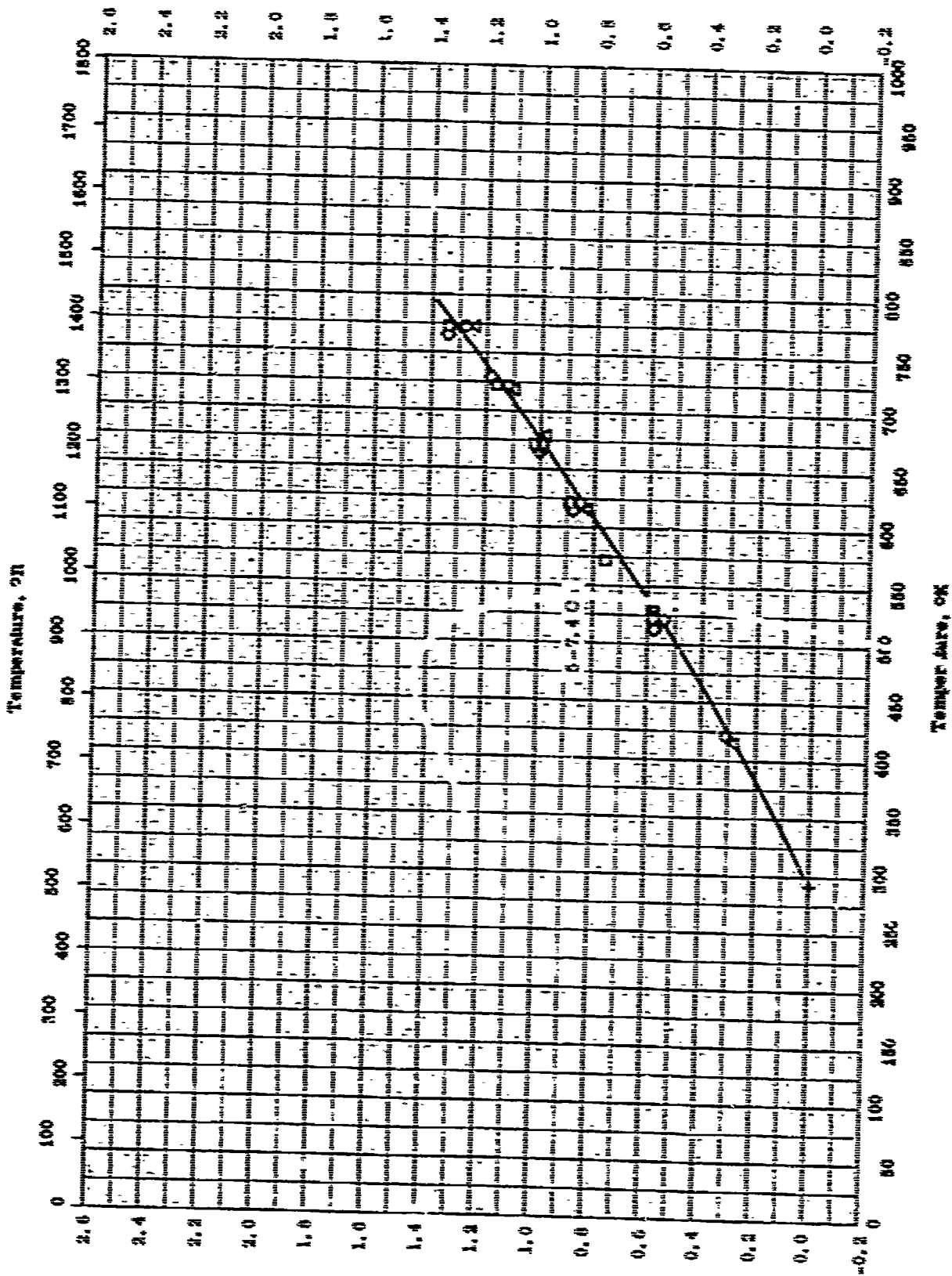
THERMAL CONDUCTIVITY --- ALUMINUM + COPPER

REFERENCE INFORMATION

| $\frac{B}{m}$ bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|----------------------|------|-------------------|------------------|-----------------------|--|
| ○ | 50-4 | 293 | | 10.24 Cu. | Anneal for 5 hrs at temperature near M. P. and furnace cooled. |
| □ | 50-4 | 293 | | 20.78 Cu. | Same as above. |
| △ | 50-4 | 293 | | 30.32 Cu. | Same as above. |
| ▽ | 50-4 | 293 | | 40.82 Cu. | Same as above. |
| ◇ | 50-4 | 293 | | 48.00 Cu. | Same as above. |

Thermal Linear Expansion, percent

11



Thermal Linear Expansion, percent

Temperature, °F

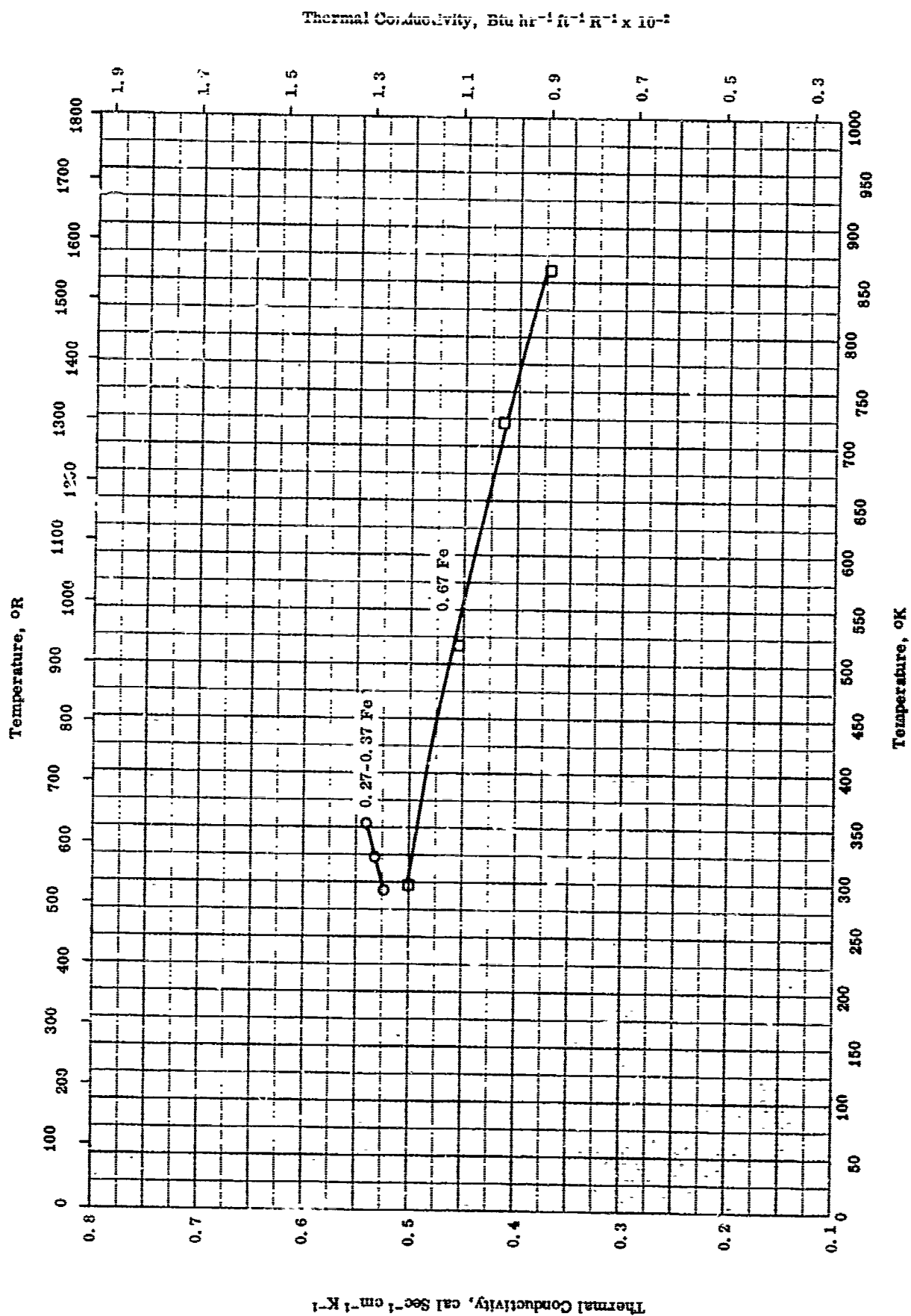
TPRC

THERMAL LINEAR EXPANSION -- ALUMINUM + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---|
| ○ | 48-1 | 293-773 | | 5.08 Cu, 0.15 Fe, 0.05 Si, Zn each, 0.02 Ti, and trace of Mg and Mn. | Cast, heated 6 hrs at 520 C, and water quenched; Initial test. |
| □ | 48-1 | 293-773 | | Same as above | Second heating. |
| △ | 48-1 | 293-773 | | 7.36 Cu, 0.15 Fe, 0.05 Si, Zn each, 0.02 Ti, and traces of Mg and Mn. | Cast, heated 6 hrs at 520 C, and water quenched; Initial test. |
| ◇ | 48-1 | 293-773 | | Same as above. | Second heating. |

TPRC

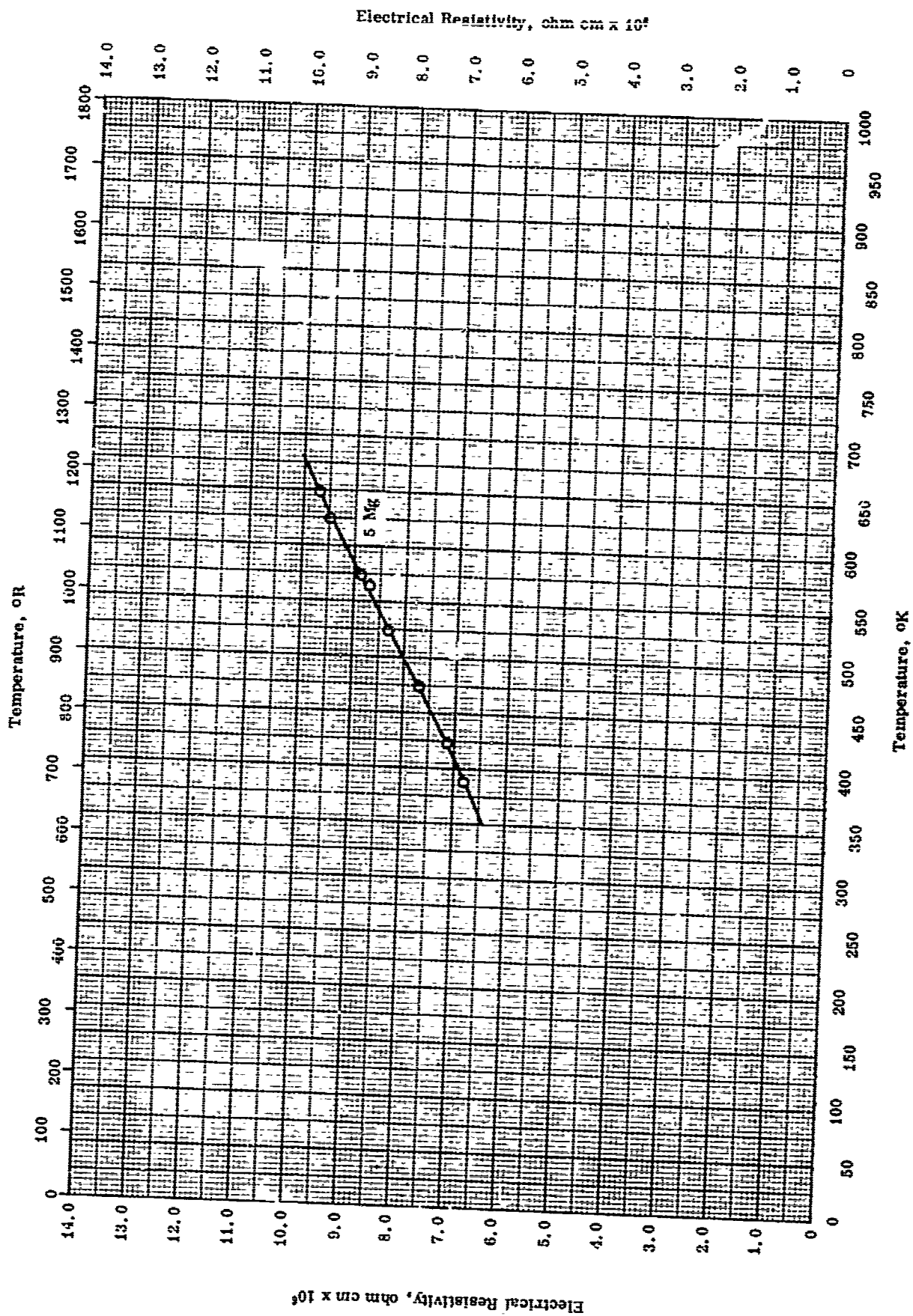


THERMAL CONDUCTIVITY -- ALUMINUM + IRON

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---------|
| □ | 47-1 | 298-923 | | 99.2 Al, 0.67 Fe, 0.10 Si, 0.01 Cu, and 0.01 > Mn and Mg. | |
| ○ | 58-3 | 293-353 | | 0.27-0.37 Fe, 0.19 Mg, 0.16 Si, 0.034 Zn, 0.021 Mn, and 0.019 Cu. | |

TPRC



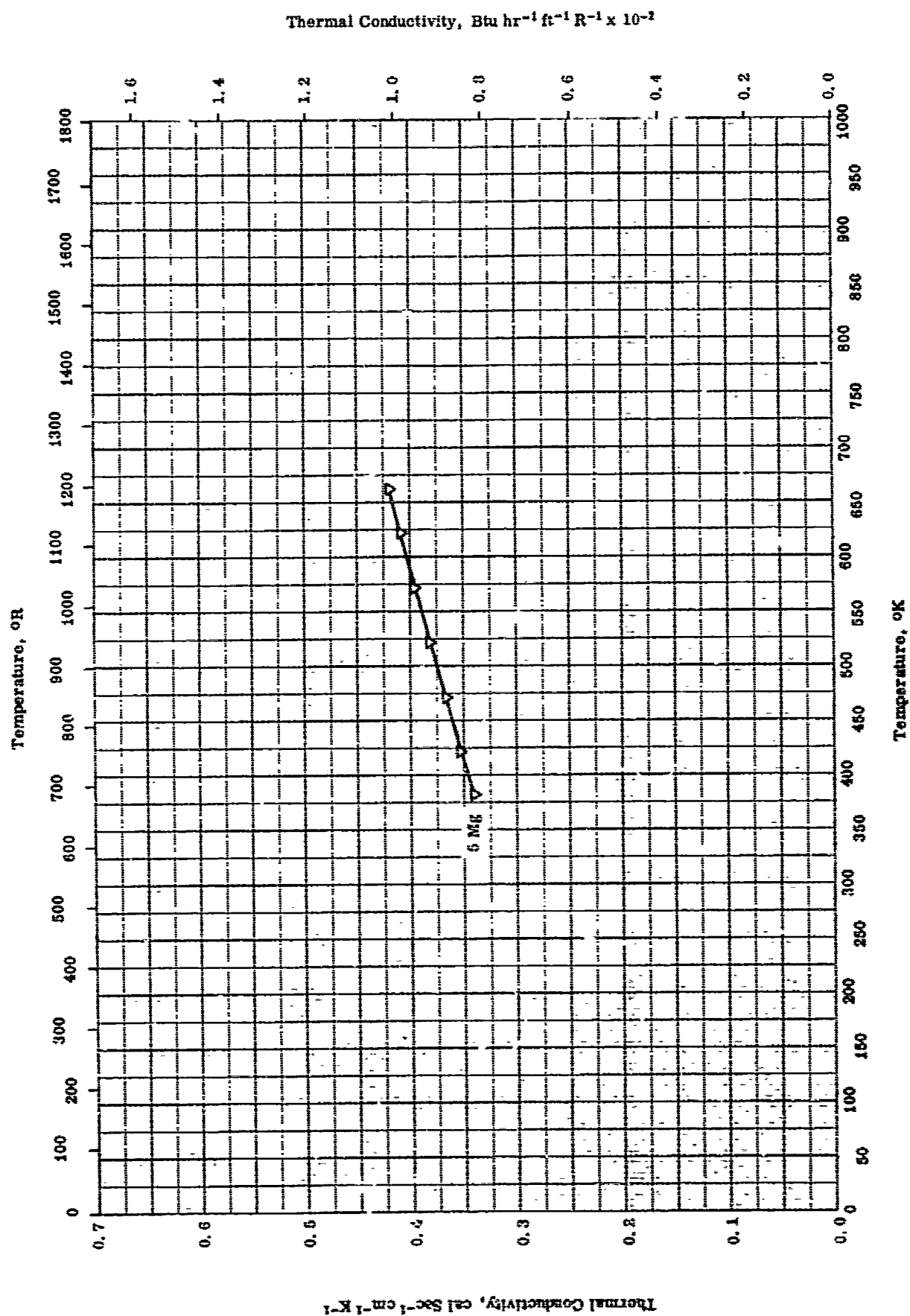
ELECTRICAL RESISTIVITY --- ALUMINUM + MAGNESIUM

ELECTRICAL RESISTIVITY -- ALUMINUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---|
| O | 40-1 | 388-649 | | Hydromilum 5 (German design.) 95 Al and 5 Mg; nominal composition. | Cast at 700 C into molds at 200 C; rolled and drawn, and then turned into rods. |

TPRC

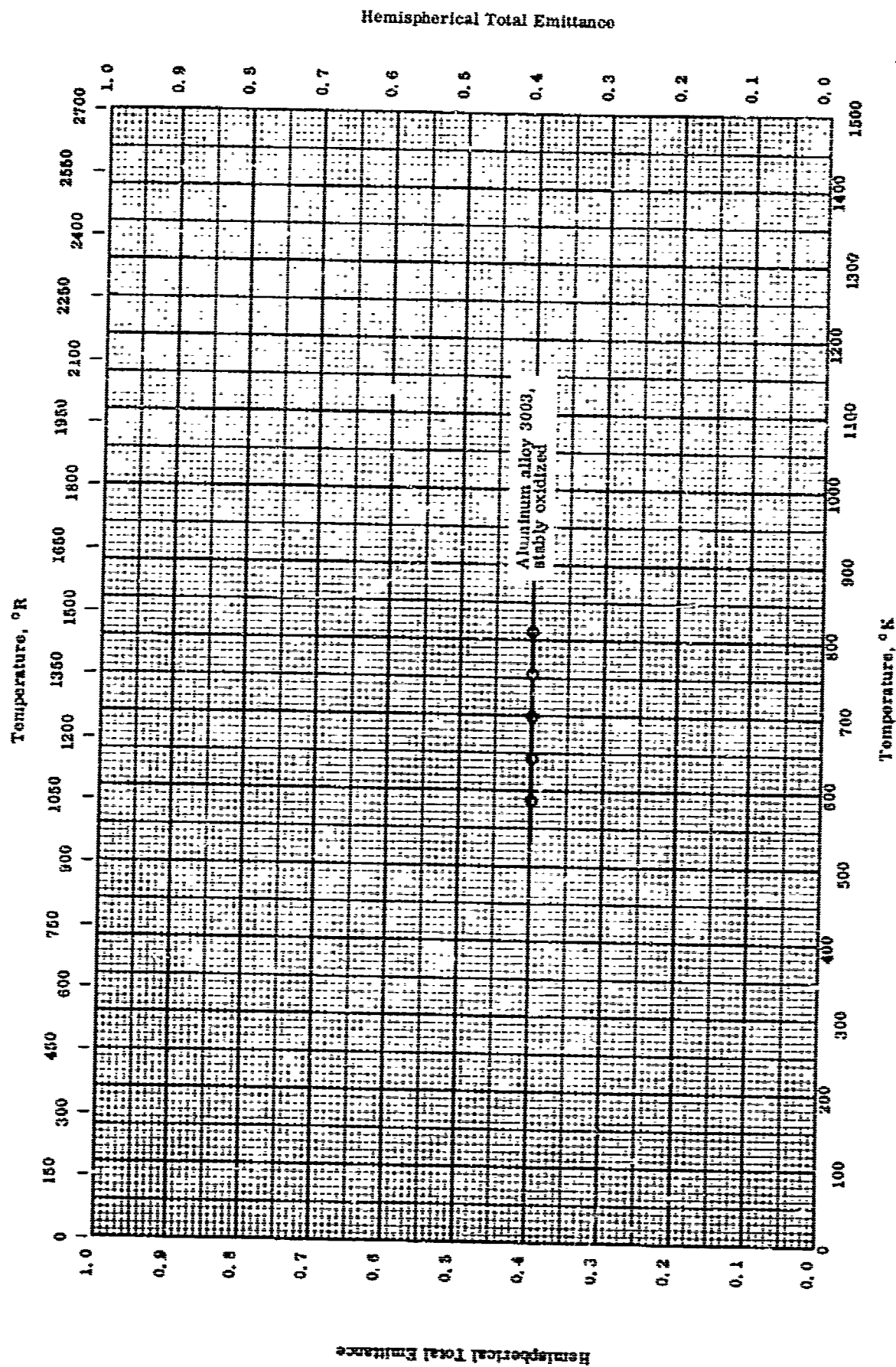


THERMAL CONDUCTIVITY -- ALUMINUM + MAGNESIUM

THERMAL CONDUCTIVITY -- ALUMINUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| ▽ | 40-1 | 372-661 | | Hydronalium 5 (German design.); 95 Al and 5 Mg; nominal composition. | Cast at 700 C into molds at 200 C; rolled and drawn, then turned into rods; radiation loss less than 5%. |



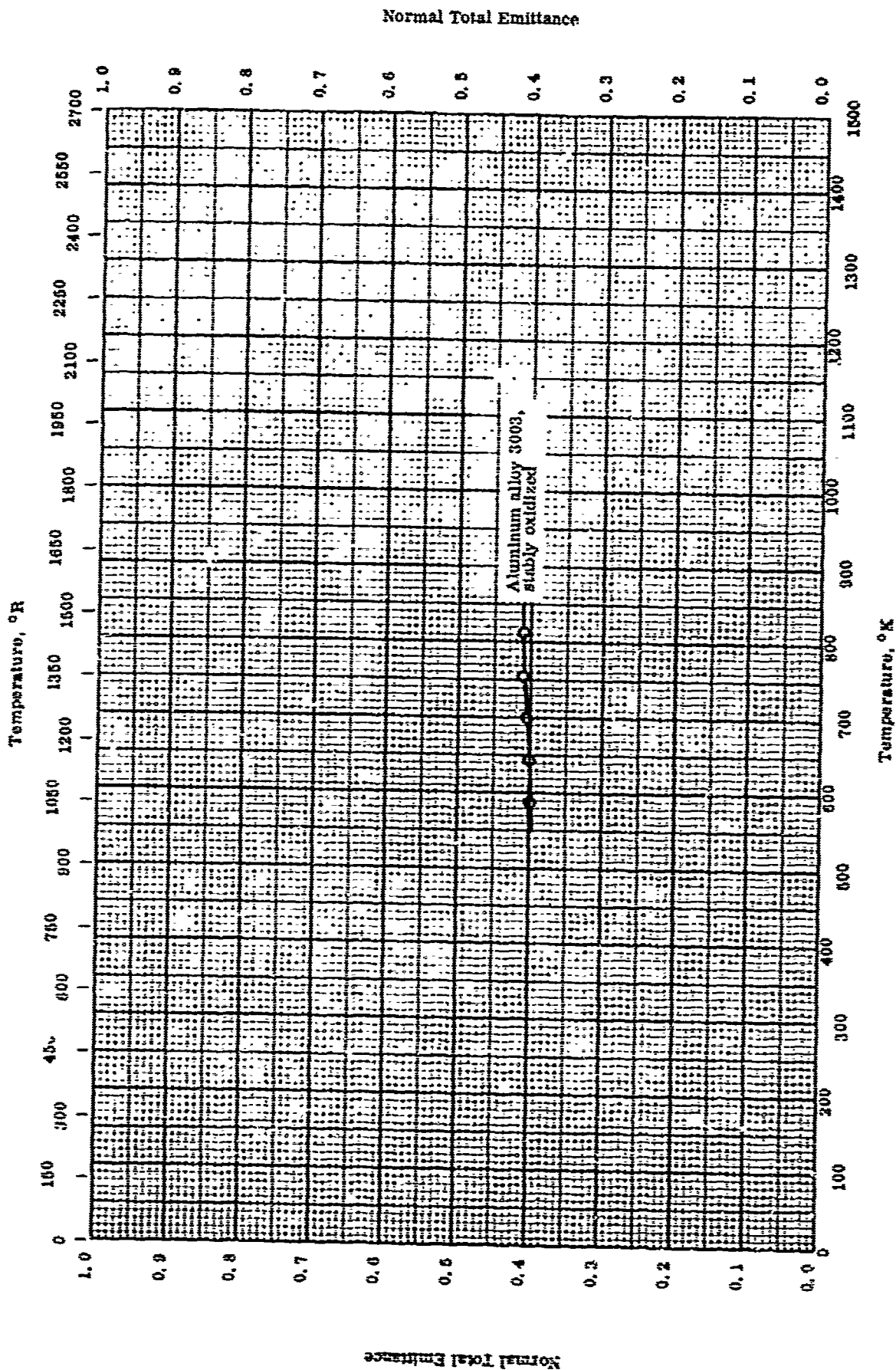
HEMISPHERICAL TOTAL EMITTANCE -- ALUMINUM + MANGANESE

HEMISPHERICAL TOTAL EMITTANCE -- ALUMINUM + MANGANESE

REFERENCE INFORMATION

| Sym No | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-------|-------------------|------------------|------------------------------|--|
| 0 | 58-24 | 580-811 | > 2 | Aluminum alloy 3003; 1.2 Mn. | Stably oxidized in quiescent air at 811 K. |

TPRC

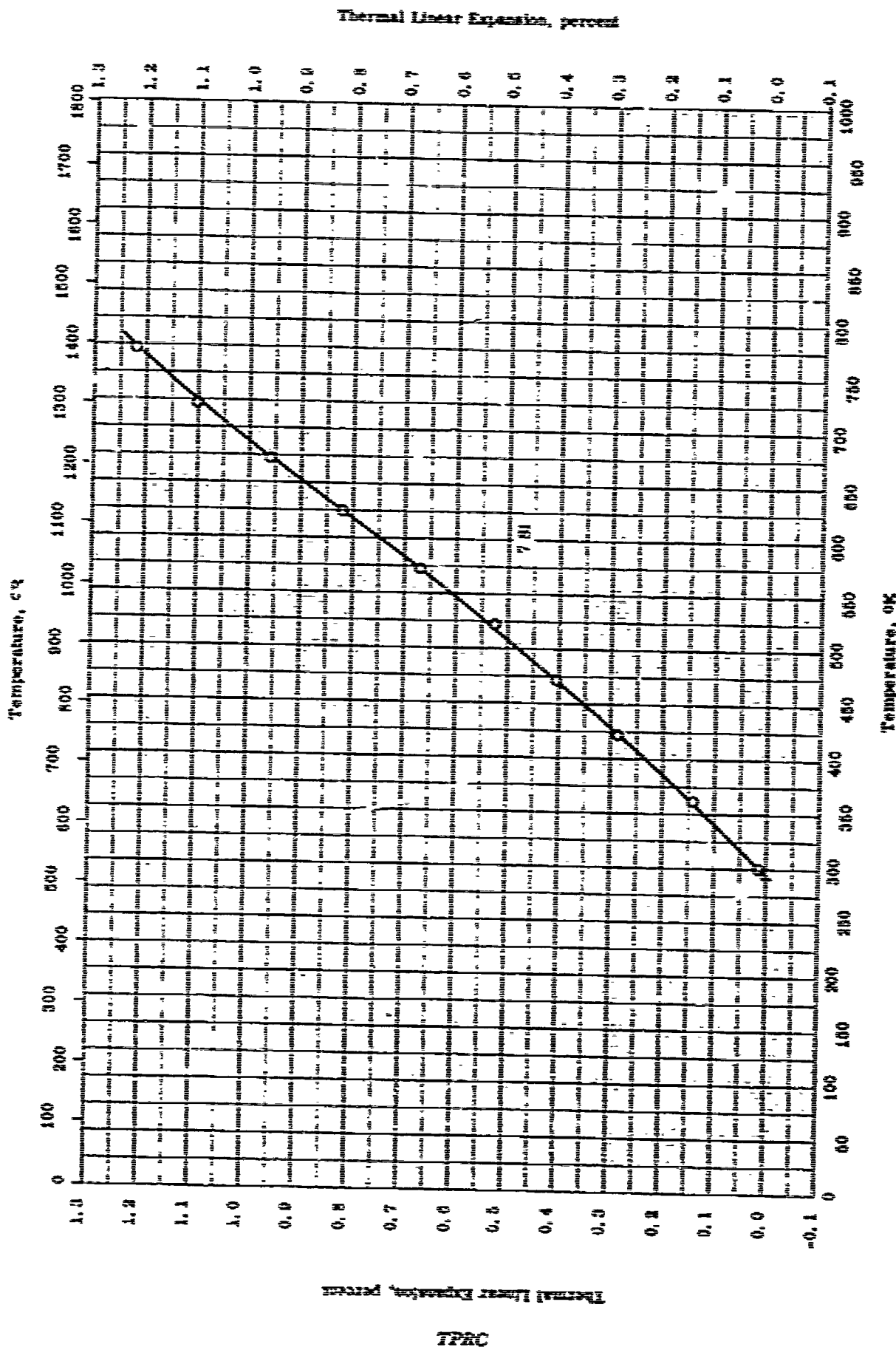


NORMAL TOTAL EMITTANCE -- ALUMINUM + MANGANESE

NORMAL TOTAL EMITTANCE -- ALUMINUM + MANGANESE

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rep. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-------------------------------|---------------------------|
| O | 58-24 | 599-611 | > 2 | Aluminum alloy 3003; 1, 2 Mn. | Stably oxidized at 811 K. |



THERMAL LINEAR EXPANSION -- ALUMINUM + SILICON

REFERENCE INFORMATION

| Sym bol | Rat. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| O | 48-1 | 293-773 | | 7.10 Si, 0.15 Fe, 0.05 Zn, 0.02 Ti, 0.01 Cu, and trace of Mg, Mn. | Cast, held 6 hrs at 520 C, and checked in water. |

TPRC

PROPERTIES OF ALUMINUM + SILVER

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------------------|----------------------|------------------------|
| ○ 10.02 Ag | 2.90 | 181 |
| ▽ 30.21 Ag | 3.45 | 215 |
| Heat of Sublimation: | cal g^{-1} | Btu lb^{-1} |
| □ 9.6 Δ_g | 1884 _{808K} | 3401 _{1455 R} |
| △ 16.5 Ag | 1853 _{836K} | 3553 _{1505 R} |

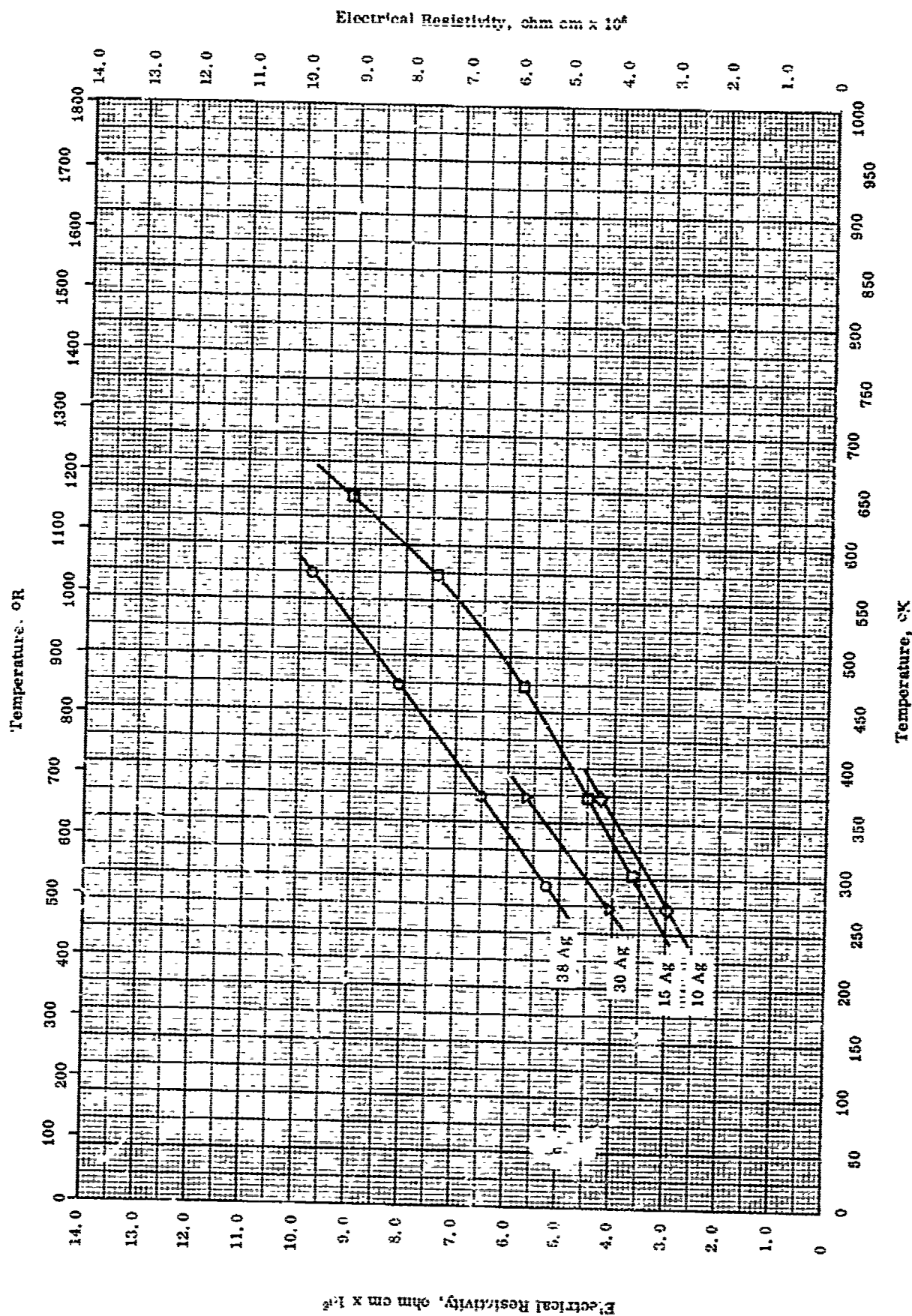
TPRC

PROPERTIES OF ALUMINUM + SILVER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| ○ | 43-1 | 298 | | 10.02 Ag; prepared from pure Ag and 99.99 pure Al. | Density by weight in air and in water. |
| ▽ | 43-1 | 298 | | 30.12 Ag; same as above. | Same as above. |
| □ | 54-21 | 808 | | 9.6 Ag; nominal. | |
| △ | 54-21 | 836 | | 16.5 Ag; nominal. | |

TPRC



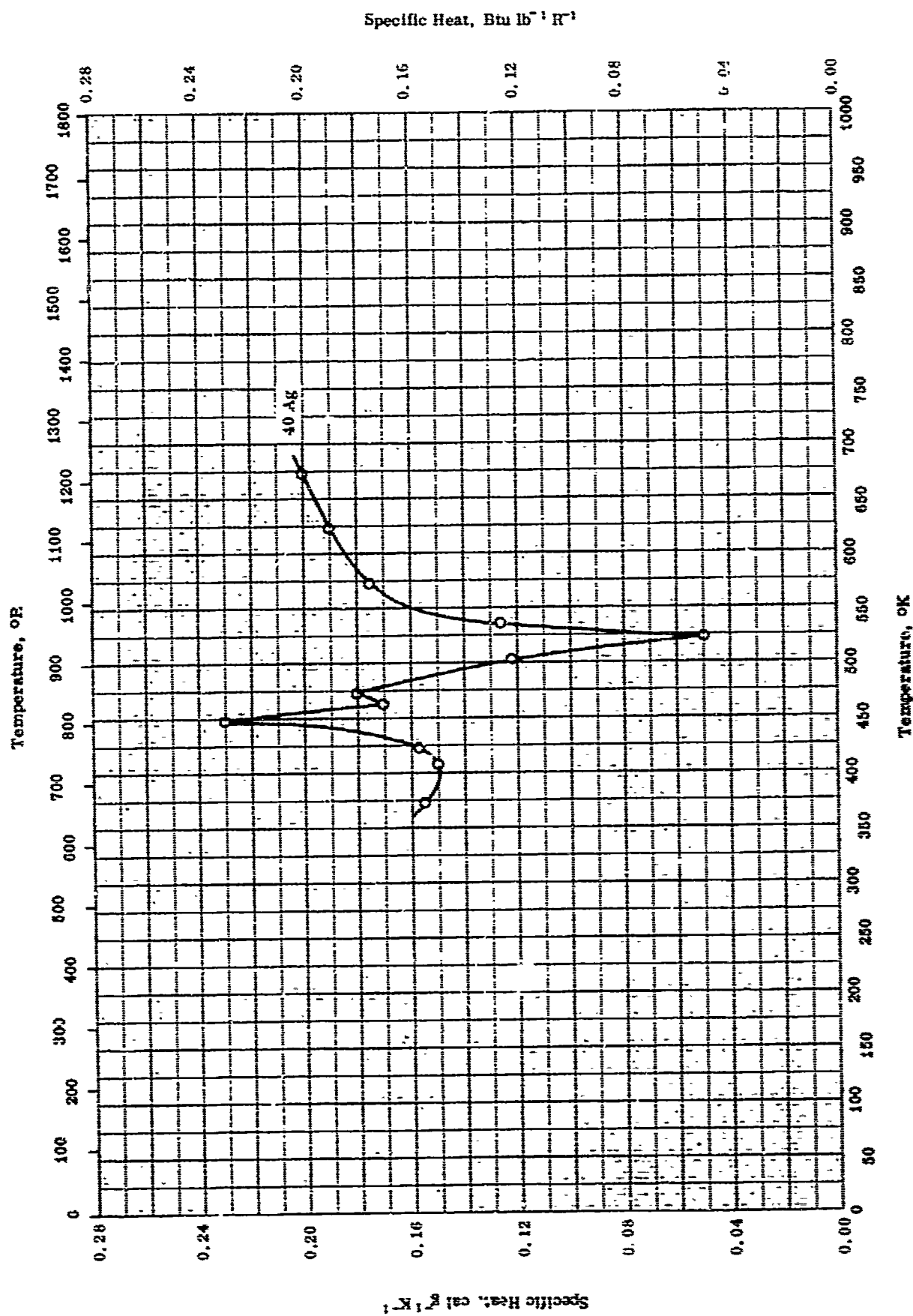
ELECTRICAL RESISTIVITY -- ALUMINUM + SILVER

ELECTRICAL RESISTIVITY -- ALUMINUM + SILVER

REFERENCE INFORMATION

| SVT Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|------------------------|---|
| ○ | 55-25 | 293-573 | | 38 Ag. | Furnace cooled 4 days from 550 C homogenizing temperature. Same as above. |
| □ | 55-26 | 303-718 | | 15 Ag. | |
| ◇ | 43-1 | 273-373 | | 89.98 Al and 10.02 Ag. | |
| ▽ | 43-1 | 273-373 | | 69.79 Al and 30.21 Ag. | |

TPRC



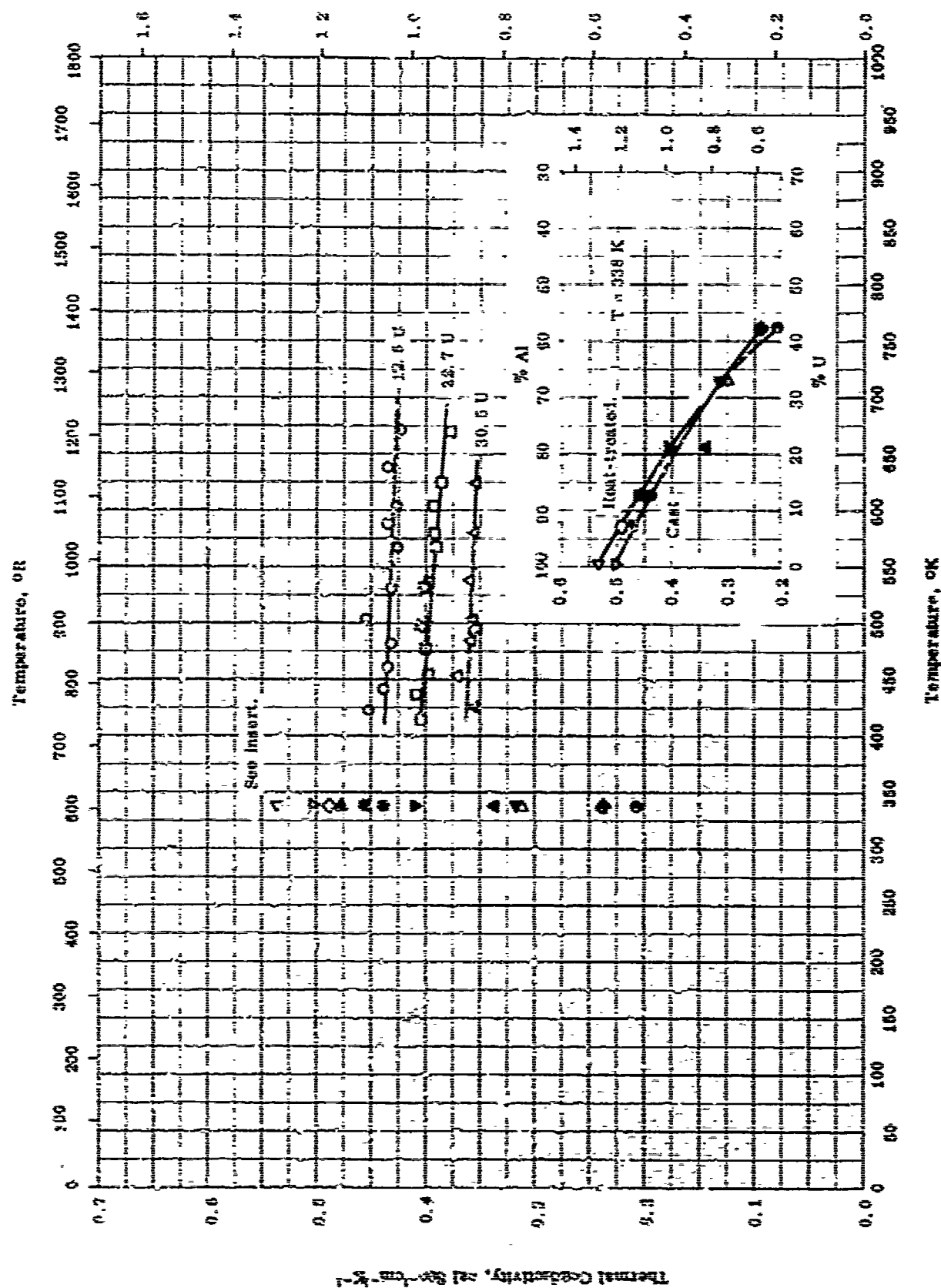
SPECIFIC HEAT --- ALUMINUM + SILVER

SPECIFIC HEAT -- ALUMINUM + SILVER

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range, °C | Rept. Error % | Sample Specifications | Remarks |
|------------|------|--------------------|------------------|-----------------------|--|
| Q | 41-3 | 373-673 | | 60 Al and 40 Ag. | Quenched from 550 C and aged 7 days at room temperature. |

TPRC

Thermal Conductivity, $\text{Btu in}^{-1}\text{ft}^{-1}\text{R}^{-1} \times 10^{-2}$ 

THERMAL CONDUCTIVITY -- ALUMINUM + URANIUM

TPR

THERMAL CONDUCTIVITY -- ALUMINUM + URANIUM

REFERENCE INFORMATION

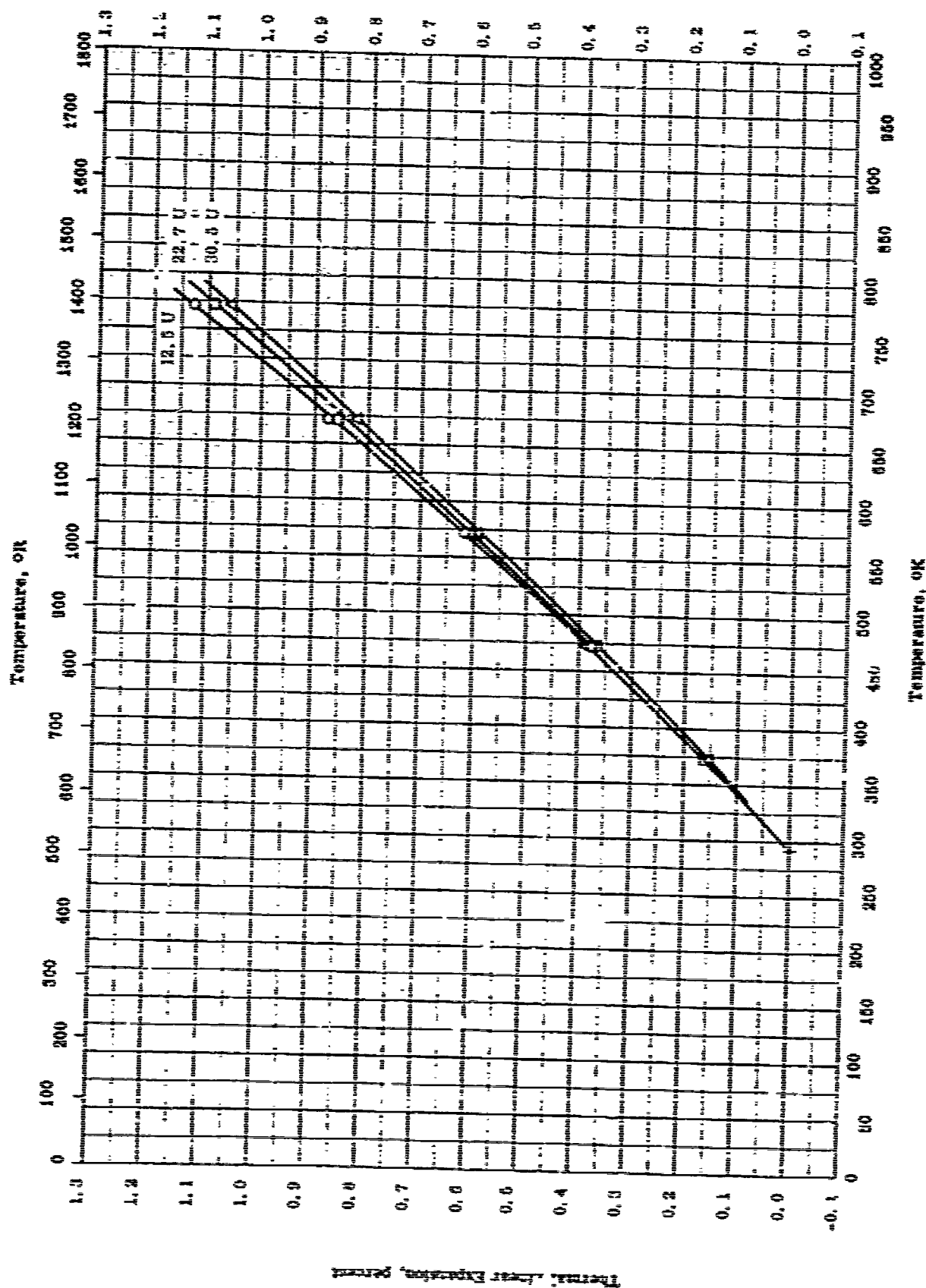
| Ref. Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|----------|------|----------------|---------------|---|---|
| ○ | 06-2 | 423-071 | | 12.0 U. | Annealed 1/2 hr at 370 C. |
| □ | 06-2 | 416-071 | | 32.7 U. | Same as above. |
| △ | 06-2 | 430-020 | | 30.3 U. | Same as above. |
| ▽ | 03-4 | 338 | <1.0 | 0.0 U, 0.10 > Fe, 0.07 > Si, 0.04 > Cu, and 0.02 > B; prepared from >99.5 reactor-grade U and 99.99 Al. | Cast after dissolving uranium in aluminum at approx. 100 C above the liquidus temperature of the alloy. |
| ◁ | 03-4 | 338 | <4.0 | Same as above. | The above sample except heat-treated at 620 C for 5 days. |
| ▷ | 03-4 | 338 | <1.0 | 0.07 U, 0.10 > Fe, 0.07 > Si, 0.04 > Cu, and 0.02 > B; same raw materials as the above sample. | Cast after dissolving uranium in aluminum at approx. 100 C above the liquidus temperature of alloys. |
| ◇ | 03-4 | 338 | <4.0 | Same as above. | Same as the above sample except heat-treated at 620 C for 5 days. |
| ● | 03-4 | 338 | <1.0 | 12.01 U, 0.10 > Fe, 0.07 > Si, 0.04 > Cu, and 0.02 > B; same raw materials as the above sample. | Cast after dissolving uranium in aluminum at approx. 100 C above the liquidus temperature of alloys. |
| ■ | 03-4 | 338 | <4.0 | Same as above. | Same as above except heat-treated at 620 C for 5 days. |
| ▲ | 03-4 | 338 | <1.0 | 21.43 U, 0.10 Fe, 0.07 Si, 0.04 Cu, and 0.02 > B; same raw materials as the above sample. | Cast after dissolving uranium in aluminum at approx. 100 C above the liquidus temperature of alloy. |

Thermal Conductivity -- ALUMINUM + URANIUM (continued)

REFERENCE INFORMATION

| Ref. No. | Temp. Range, °K | Ref. Error, % | Sample Specifications | Remarks |
|----------|-----------------|---------------|---|---|
| 63-4 | 338 | <4.0 | Same as above. | Same as above except heat-treated at 620 C for 5 days. |
| 63-4 | 338 | <1.0 | 92.94 U, 0.10 Fe, 0.07 Si, 0.04 Ca, and 0.02 B; same raw materials as the above sample. | Cast after dissolving uranium in aluminum at approx. 100 C above the liquidus temperature of alloy. |
| 63-4 | 338 | <4.0 | Same as above. | Same as above except heat-treated at 620 C for 5 days. |
| 63-4 | 338 | <1.0 | 42.49 U, 0.10 Fe, 0.07 Si, 0.04 Ca, and 0.02 B; same raw materials as the above sample. | Cast after dissolving uranium in aluminum at approx. 100 C above the liquidus temperature of alloy. |
| 63-4 | 338 | <4.0 | Same as above. | Same as above except heat-treated at 620 C for 5 days. |

Thermal Linear Expansion, percent



THERMAL LINEAR EXPANSION - ALUMINUM + URANIUM

THERMAL LINEAR EXPANSION - ALUMINUM + URANIUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °C | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|------------------------------|
| 0 | 07-04 | 200-770 | | 12.0 O 0.0 in. dia. by 3.40 in. long specimen. | Prepared from forged alloys. |
| 1 | 07-04 | 200-770 | | 12.7 O same as above. | Same as above. |
| 2 | 07-04 | 200-770 | | 30.0 O 1/4 same as above. | Same as above. |

TPRC

PROPERTIES OF BARIUM + STRONTIUM

REPORTED VALUES

| | | |
|-----------------|---------------------|----------------------|
| Melting Point: | K | R |
| ○ 0.4 Sr | 983 | 1770 |
| Heat of Fusion: | cal g ⁻¹ | Btu lb ⁻¹ |
| □ 0.4 Sr | 13.3 ± 0.6 | 24.0 ± 1 |

TPRC

PROPERTIES OF BARIUM + STRONTIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °C | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| O | 50-10 | 950-983 | | 0.4 Sr, 0.1 Ca, 0.02 Fe, 0.01 each Mg, Cu, and Mn, and traces of Si. | Δh_f from steps in enthalpy and temperature curve. |
| □ | 50-10 | --- | | Same as above. | |

PROPERTIES OF BERYLLIUM + ALUMINUM

REPORTED VALUES

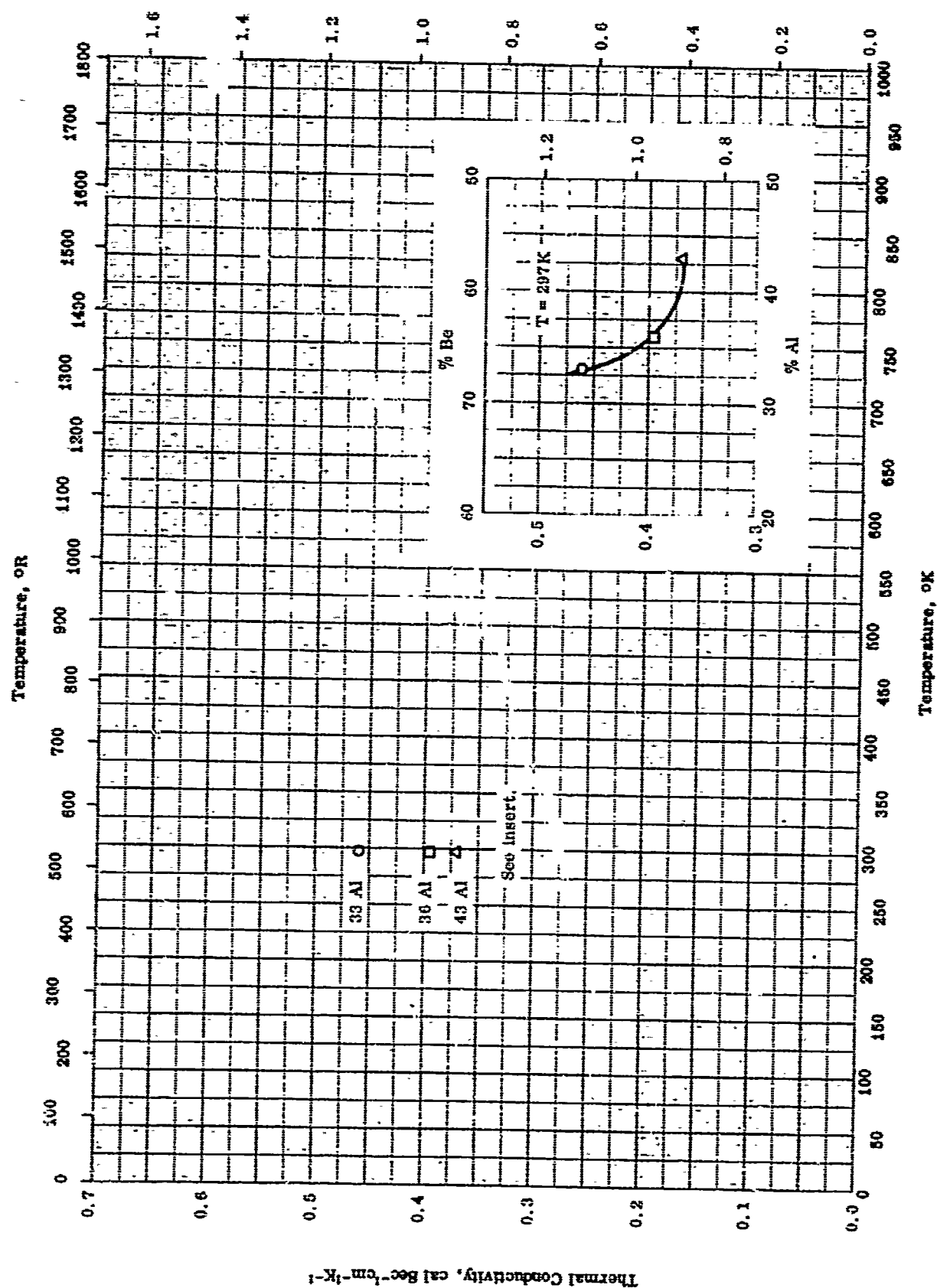
| Density: | | g cm^{-3} | lb ft^{-3} |
|----------|---------|--------------------|---------------------|
| ○ | 0.21 Al | 1.73 | 108 |
| □ | 0.21 Al | 1.80 | 112 |

PROPERTIES OF BERYLLIUM + ALUMINUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| O | 49-10 | 288 | | 98.54 Be, 0.21 Al, 0.19 Mg, 0.164 Fe, 0.084 Si, 0.036 Ca, 0.016 Cr, 0.013 Cu, 0.011 Mn, 0.008 Ni, 0.008 Pb, 0.0006Sn, 0.005 B, and 0.00003 Cd. | Max. density by compacting at 116,000 psi, 3 hrs at 1200 C in vacuum. |
| □ | 49-10 | 288 | | Same as above. | Max. density by slintering 30 min. 550 C in A atm |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1}\text{ft}^{-1}\text{R}^{-1} \times 10^{-2}$ 

THERMAL CONDUCTIVITY -- BERYLLIUM + ALUMINUM

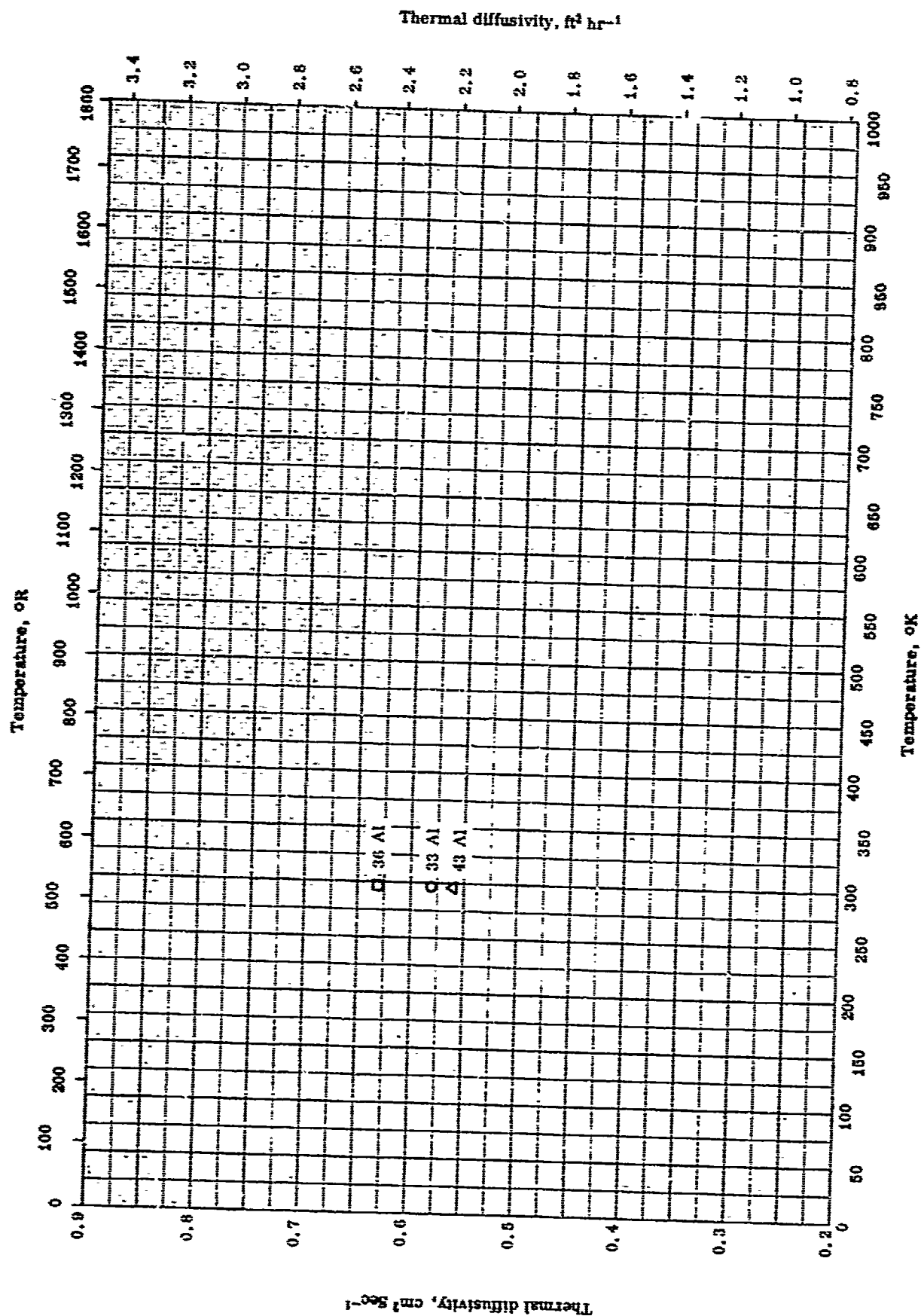
TPRC

THERMAL CONDUCTIVITY -- BERYLLIUM + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---------|
| ○ | 64-1 | 297 | | 33 Al; density 2.00 g cm ⁻³ . | |
| □ | 64-1 | 297 | | 76 Al; density 2.07 g cm ⁻³ . | |
| △ | 64-1 | 297 | | 43 Al; density 2.14 g cm ⁻³ . | |

TPRC

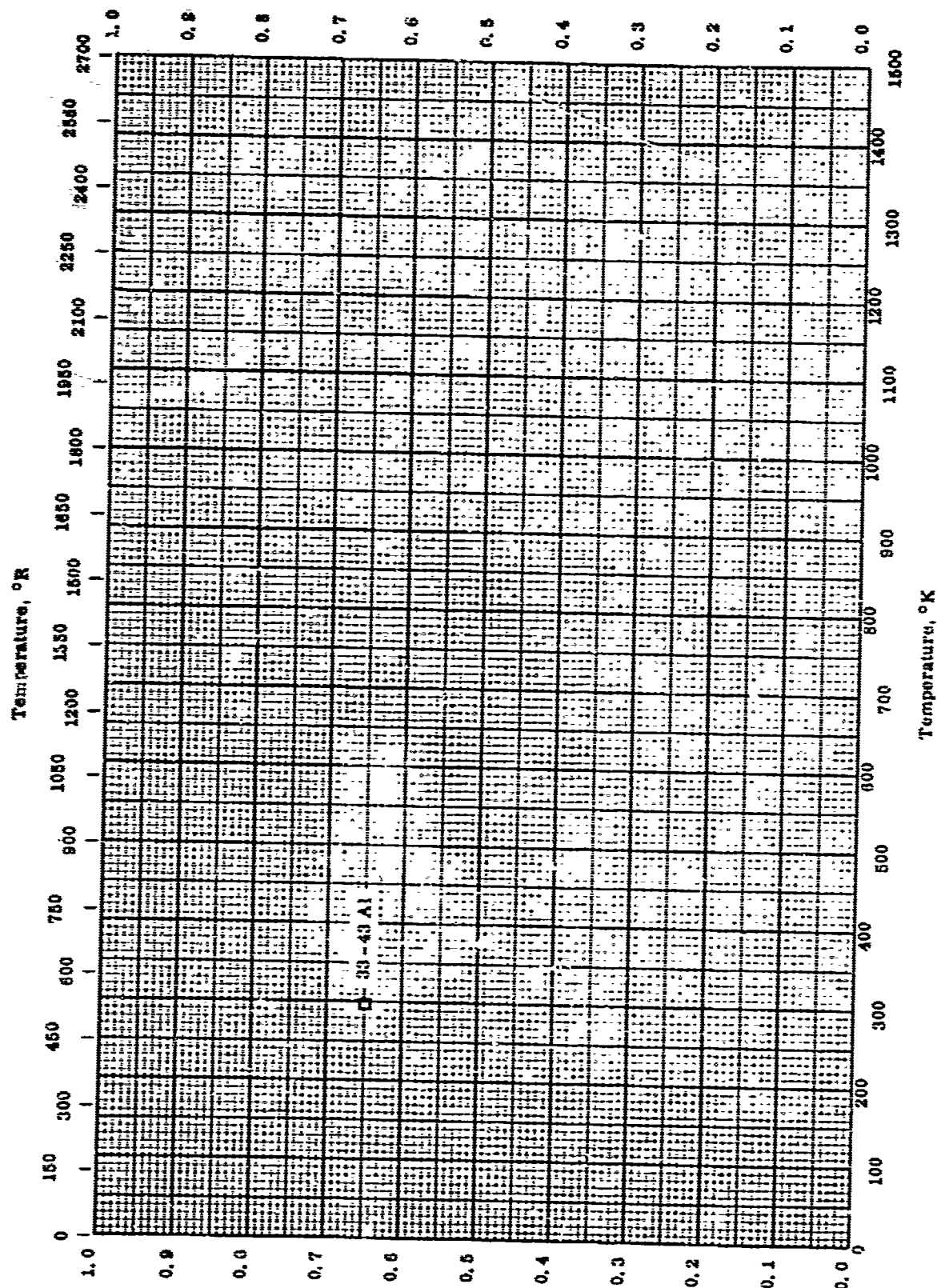


THERMAL DIFFUSIVITY -- BERYLLIUM + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---------|
| ○ | 04-1 | 297 | | 07 Be and 33 Al; density 2.05 g cm^{-3} . | |
| □ | 04-1 | 297 | | 04 Be and 36 Al; density 2.07 g cm^{-3} . | |
| △ | 04-1 | 297 | | 07 Be and 43 Al; density 2.14 g cm^{-3} . | |

Normal Total Emittance



Normal Total Emittance :

TPRC

NORMAL TOTAL EMITTANCE --- BERYLLIUM + ALUMINUM

NORMAL TOTAL EMITTANCE -- BERYLLIUM + ALUMINUM

REFERENCE INFORMATION

| Spec No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|------|-------------------|------------------|---|-----------------------------------|
| □ | 04-1 | 207 | | Three samples: (1) 33 Al; density 2.05 gm cm ⁻³ (2) 36 Al; density 2.07 gm cm ⁻³ (3) 43 Al; density 2.14 gm cm ⁻³ | Same value for all three samples. |

PROPERTIES OF BORON + IRON

REPORTED VALUES

| Heat of Sublimation: | cal g ⁻¹ | Btu lb ⁻¹ |
|----------------------|---------------------|----------------------|
| △ 1.0 Fe | 13020 ± 180 | 23440 ± 330 |
| ◇ 1.0 Fe | 12800 ± 400* | 23100 ± 800* |

* Most probable value for alloys of this composition.

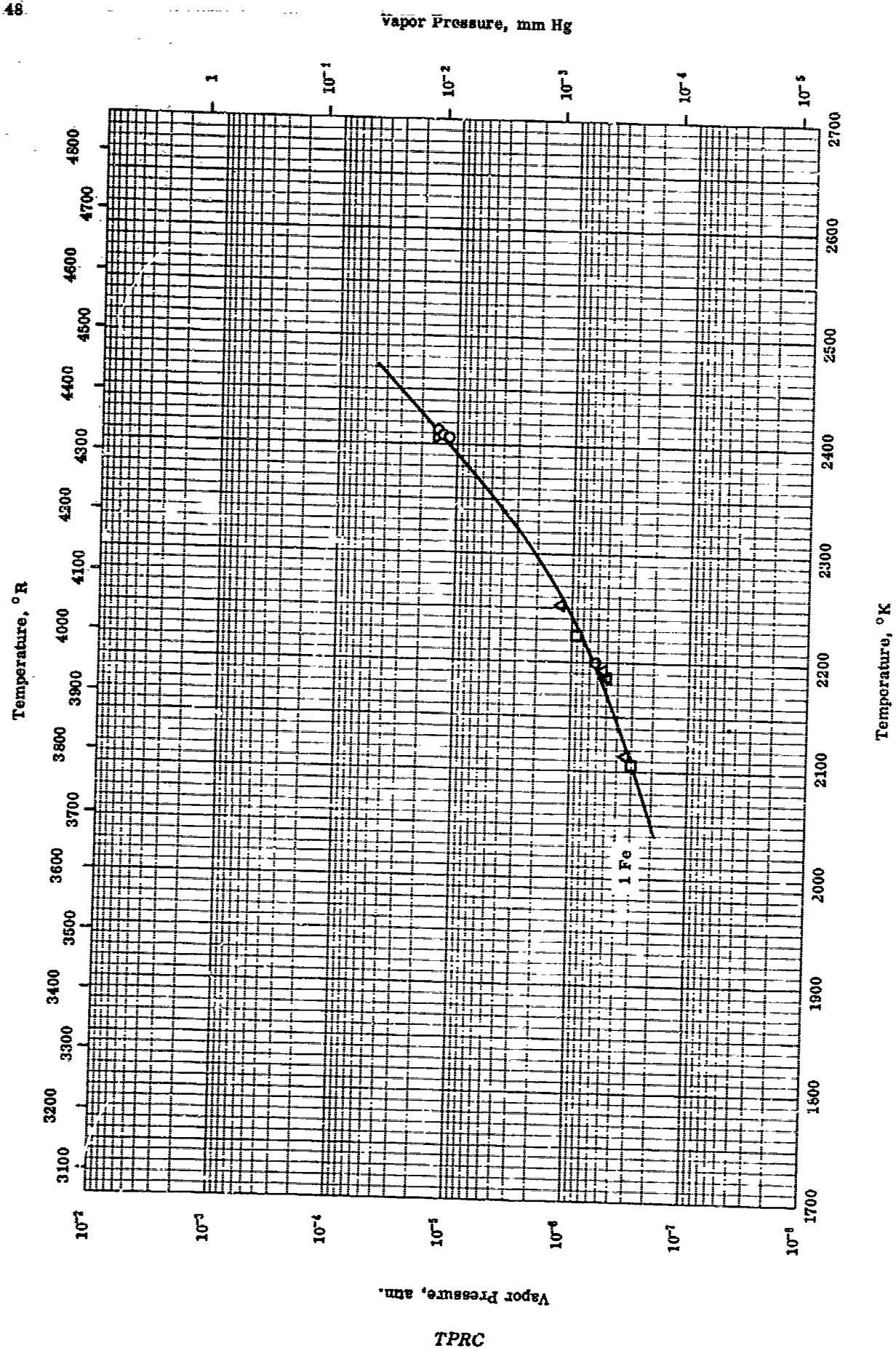
TPRC

PROPERTIES OF BORON + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-------------------------------------|---------------------------------------|
| Δ | 53-21 | 298 | | 1 Fe and 0.13 C. Samp. as above. | Δ h _g from vapor pressure. |
| ◇ | 57-13 | 298 | | | Same as above. |

TPRC



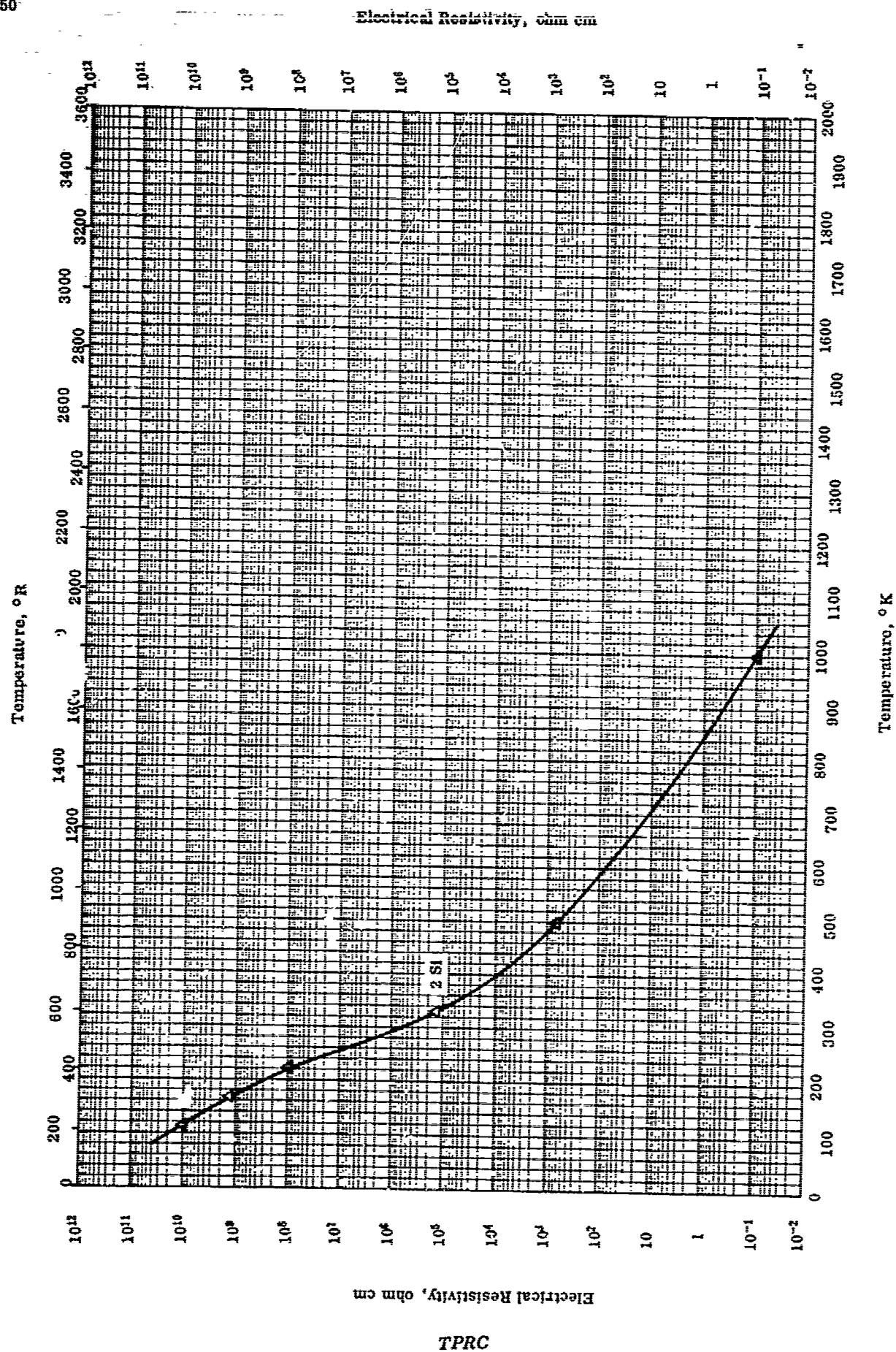
VAPOR PRESSURE --- BORON + IRON

VAPOR PRESSURE -- BORON + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|-----------------------------|
| △ | 57-13 | | | 1 Fe, 0.13 C. | Carbon crucibles. |
| ▽ | 57-13 | | | 1 Fe, 0.13 C. | Tantalum crucibles. |
| ○ | 57-13 | | | 1 Fe, 0.13 C. | ZrB ₂ crucibles. |
| □ | 57-13 | | | 1 Fe, 0.13 C. | Early 1953 data. |

TPRC



ELECTRICAL RESISTIVITY -- BORON + SILICON

ELECTRICAL RESISTIVITY -- BORON + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|------------------------|--|
| Δ | 57-27 | 111-1000 | | 2 Si and 0.03% others. | Prepared by reduction of B Cl ₃ with H ₂ on heated tungsten at 1530 C. |

TPRC

PROPERTIES OF CADMIUM + SILVER

REPORTED VALUES

| Melting Point: | K | R |
|-----------------|---------------------|----------------------|
| ○ 31.6 Ag | 865 | 1558 |
| Heat of Fusion: | cal g ⁻¹ | Btu lb ⁻¹ |
| □ 31.6 Ag | 18.2 ± 1 | 32.8 ± 1.6 |

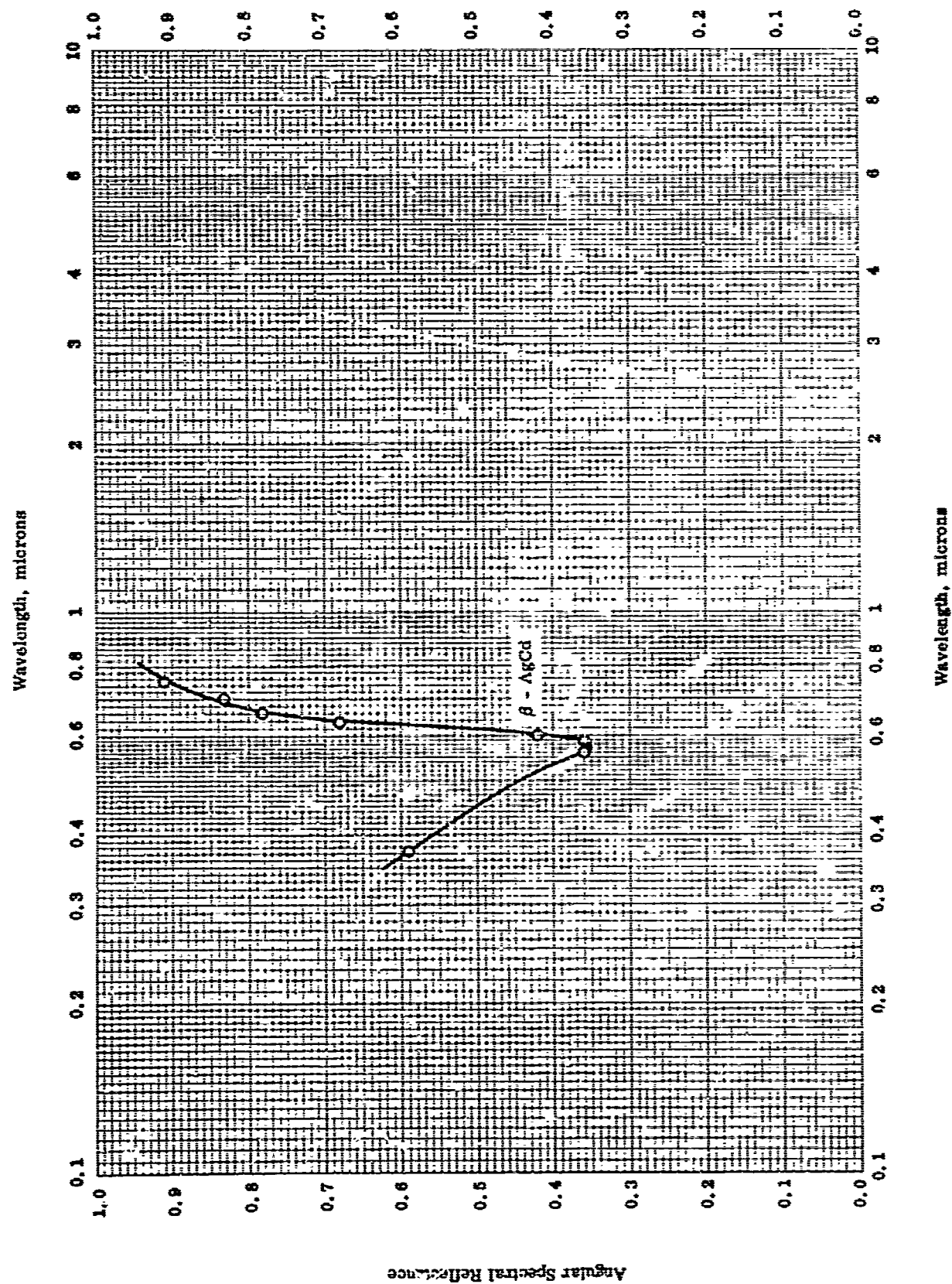
TPRC

PROPERTIES OF CADMIUM + SILVER

REFERENCE INFORMATION

| Sym- bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|------|-------------------|------------------|-----------------------|---|
| ○ | 43-4 | 866 | ± 2.3 | 68.4 Cd; ε- phase | From enthalpy data by drop method copper block calorimeter. |
| □ | 43-4 | 866 | | Same as above. | |

Angular Spectral Reflectance



ANGULAR SPECTRAL REFLECTANCE -- CADMIUM + SILVER

ANGULAR SPECTRAL REFLECTANCE -- CADMIUM + SILVER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|-----------------|------------------------------|---|
| ○ | 61-24 | 298 | 0.375-0.75 | | β - AgCd; 2000 Å film. | Vacuum evaporated on glass; 45 degree illumination and 45 degree viewing; data extracted from smooth curve. |

PROPERTIES OF CALCIUM + MAGNESIUM

REPORTED VALUES

Melting Point:

K

R

□ 0.3 Mg

1122

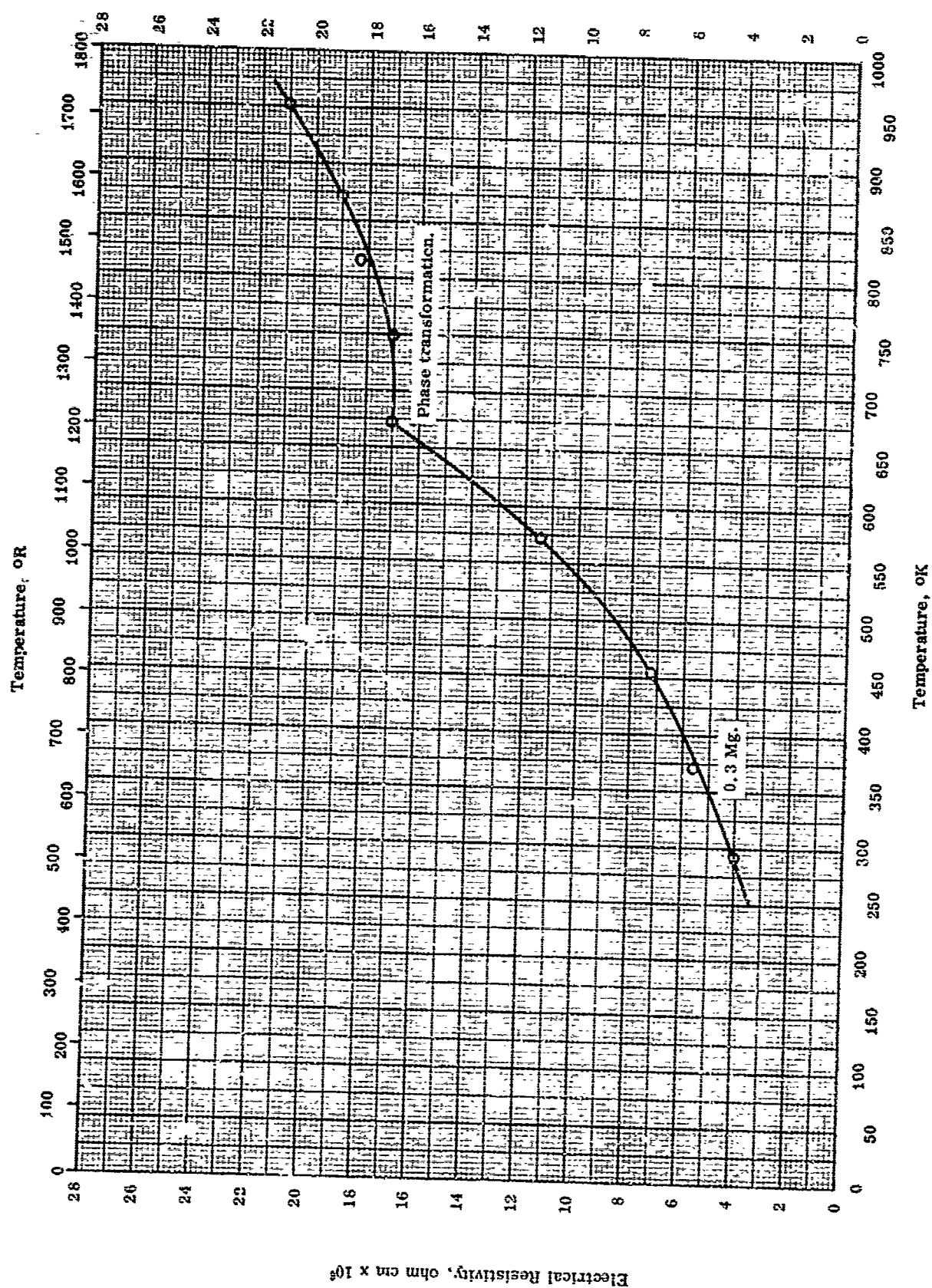
2020

PROPERTIES OF CALCIUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Rel. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|-------------------|
| □ | 50-28 | 2020 | | 99.60 Ca, 0.3 Mg, 0.3225 N, 0.006 P, 0.004 Mn, and 0.001 Al. | Triple distilled. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$ 

TPRC

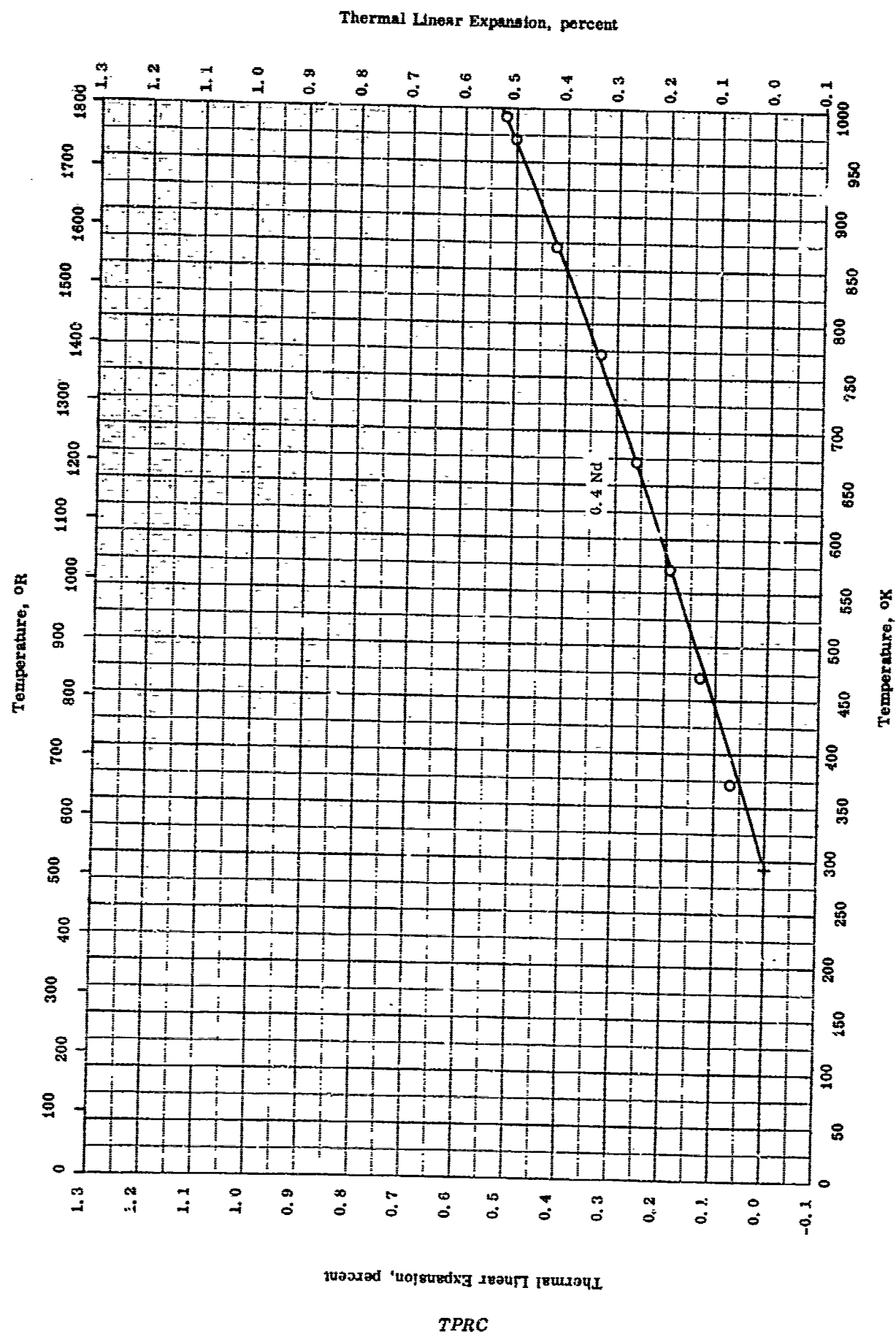
ELECTRICAL RESISTIVITY -- CALCIUM + MAGNESIUM

ELECTRICAL RESISTIVITY -- CALCIUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|-------------------|
| O | 56-28 | 293-973 | | 99.86 Ca, 0.3 Mg, 0.025 N, 0.006 Fe, 0.004 Mn, and 0.001 Al. | Triple distilled. |

TPRC



Thermal Linear Expansion -- CERIUM + NEODYMIUM

THERMAL LINEAR EXPANSION -- CERIUM + NEODYMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| O | 57-51 | 293-995 | | 0.4 Nd, 0.05 Pr and La each, 0.04 Fe, N ₂ , Ca each, 0.03 Si, and 0.02 C. | Data obtained during heating; cooling data not shown because sample softened. |

TPRC

PROPERTIES OF CHROMIUM + IRON

REPORTED VALUES

Melting Point:

O 0.3 Fe

K

2176

R

2917

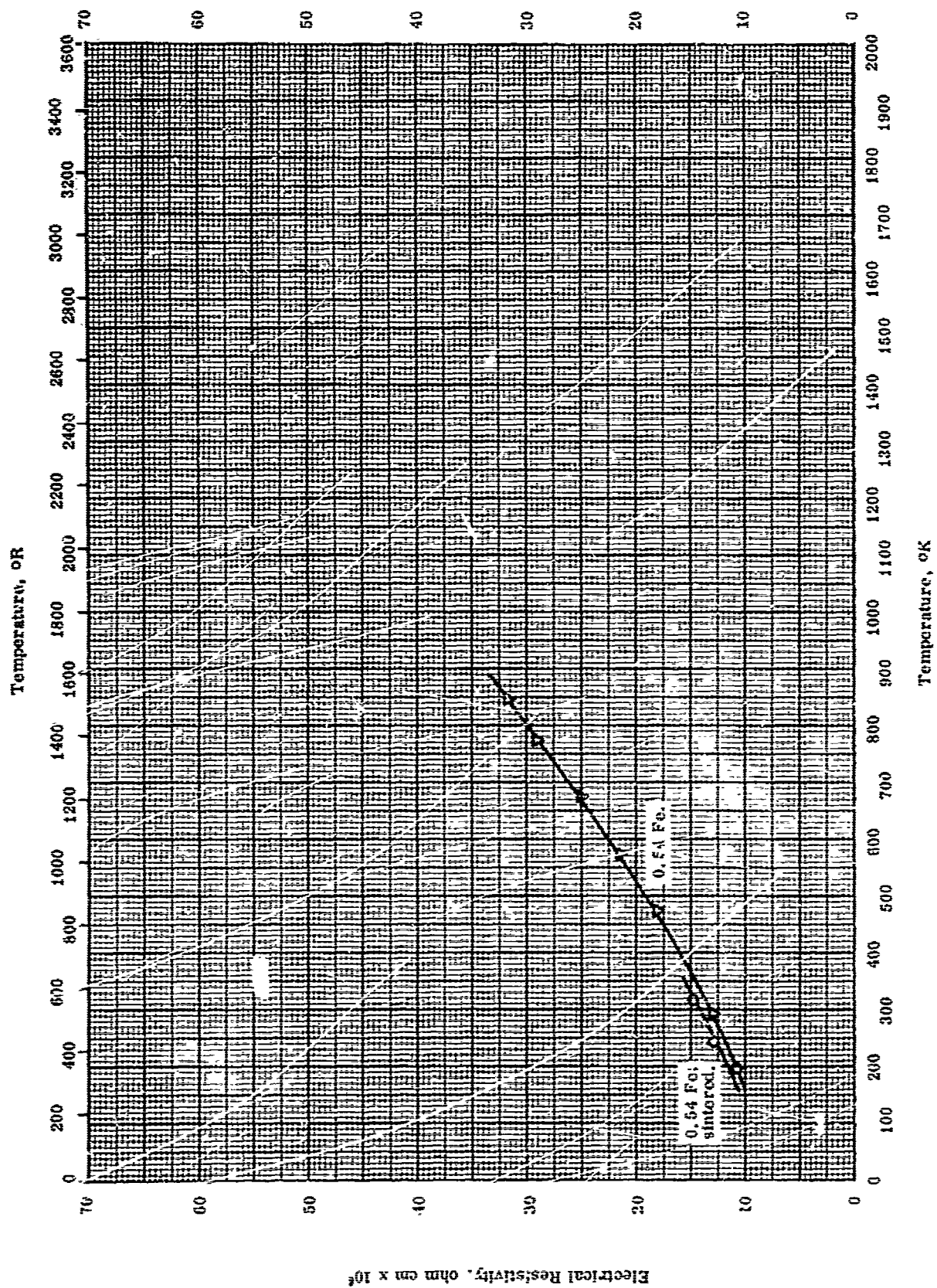
TPRC

PROPERTIES OF CHROMIUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| O | 52-15 | 2160-2180 | | Electrolytic; 0.3 Fe, 0.08 O, 0.03 Si, 0.004 S, 0.002 N, 0.091 Mo, and negligible C. | Annealed in purified H ₂ for 100 hrs at 1375 C; melted in stabilized zirconia crucible under purified A atm. |

Electrical Resistivity, ohm cm x 10⁶

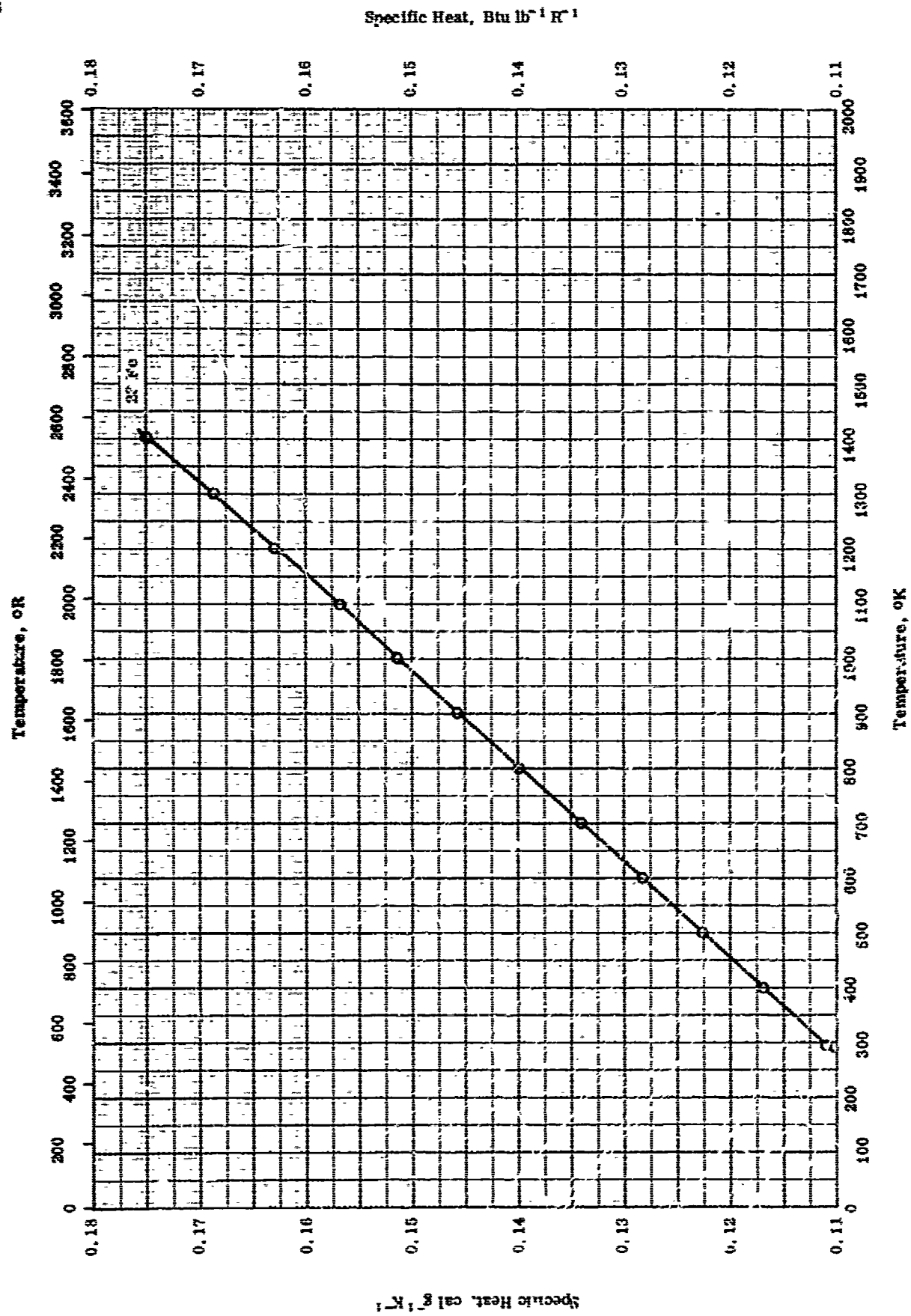


ELECTRICAL RESISTIVITY -- CHROMIUM + IRON

ELECTRICAL RESISTIVITY -- CHROMIUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--------------------------------|--|
| ▽ | 53-17 | 293-848 | | 0.54 Fe, 0.14 Si, and 0.014 S. | Made by decomposing Cr hydride; annealed 40 hrs at 700 C; auth. reported $\gamma/\gamma_{\text{Fe}}$; γ_{Fe} not given. |
| ○ | 53-17 | 198-373 | | Same as above. | Same as the above; O ₂ and N ₂ content reduced by sintering in H ₂ atoms. |



SPECIFIC HEAT -- CHROMIUM + IRON

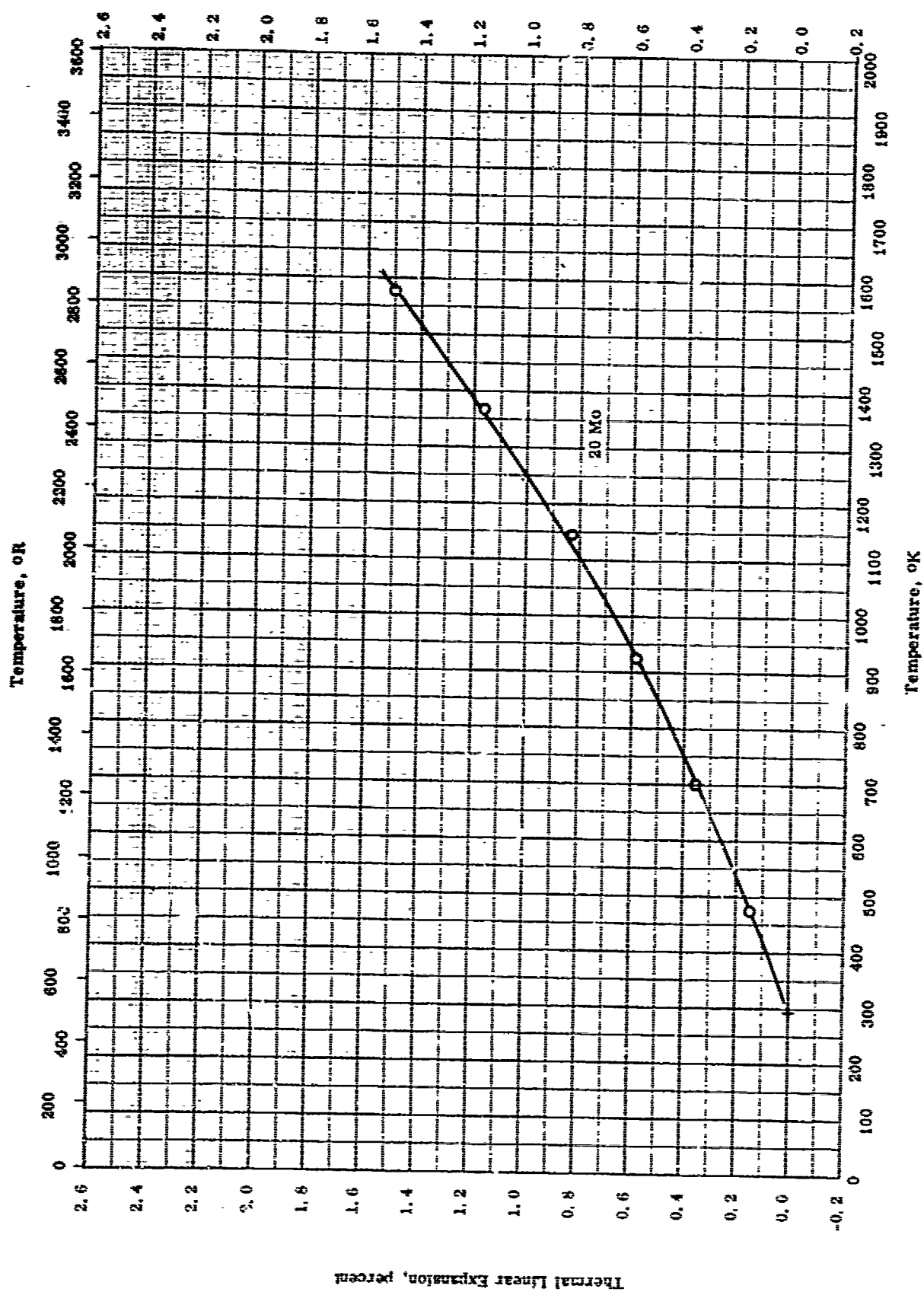
TPRC

SPECIFIC HEAT -- CHROMIUM + IRON

REFERENCE INFORMATION

| Sym Co | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-------|-------------------|------------------|--|---|
| O | 59-11 | 298-1400 | ± 0.5 | Sample No. 80 Cr; 77.2 Cr and 22.8 Fe. | Homogenized for 4 days at 1350 C under helium; air cooled to room temperature. |

Thermal Linear Expansion, percent



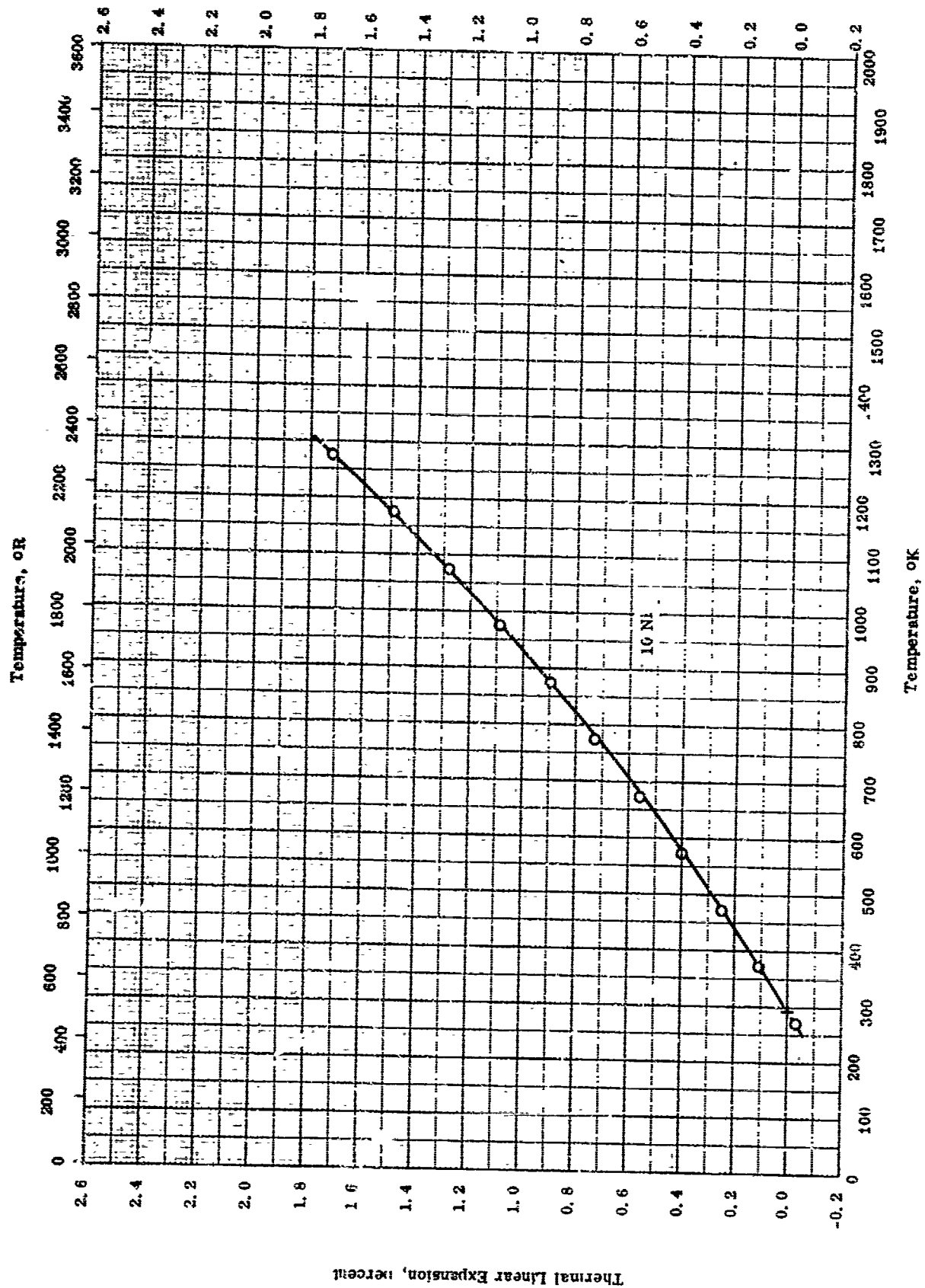
THERMAL LINEAR EXPANSION --- CHROMIUM + MOLYBDENUM

THERMAL LINEAR EXPANSION -- CHROMIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|--|--|
| Q | 54-28 also 55-40 | 293-1573 | | 80 Cr and 20 Mo, prepared from 99 + pure Cr and 99.75 + pure Mo. | Initial run discarded as bends in sight wires came out during heating; results given from cooling curve plus later runs. |

Thermal Linear Expansion, percent



THERMAL LINEAR EXPANSION -- CHROMIUM + NICKEL

THERMAL LINEAR EXPANSION -- CHROMIUM + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---------|
| O | 41-5 | 273-1273 | | Chromium; approx. analysis: 90 Cr, 10 Ni, and trace Fe. | |

TPRC

PROPERTIES OF CHROMIUM + SILICON

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| ○ 0.29 Si | 7.07 | 441 |
| □ 0.53 Si | 6.86 | 428 |

TPRC

PROPERTIES OF CHROMIUM + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|-------------|
| ○ | 41-4 | 298 | | 99.2 Cr, 0.29 Si, and 0.05 Mn. | Hot-swaged. |
| □ | 41-4 | 298 | | 96.7 Cr, 0.53 Si, 0.09 C, 0.065 N, 0.02 Fe, and 0.02 Mn. | Hot-swaged. |

TPRC

PROPERTIES OF CHROMIUM + TUNGSTEN

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| O 30 W | 8.68 | 542 |

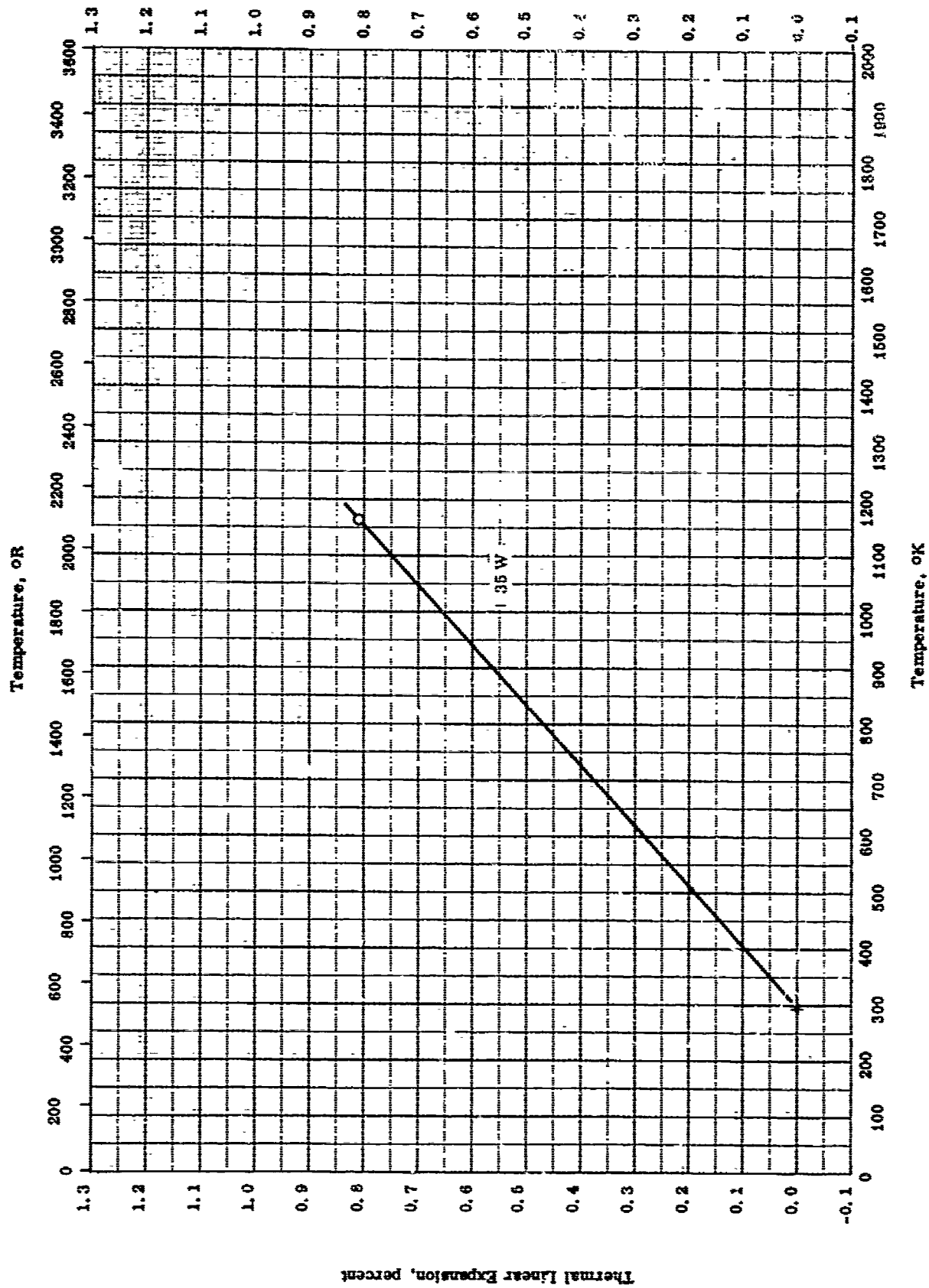
PROPERTIES OF CHROMIUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---------------------------|----------|
| O | 46-2 | 298 | | 70 Cr, 30 W, and 0.026 C. | As cast. |

TPRC

Thermal Linear Expansion, percent



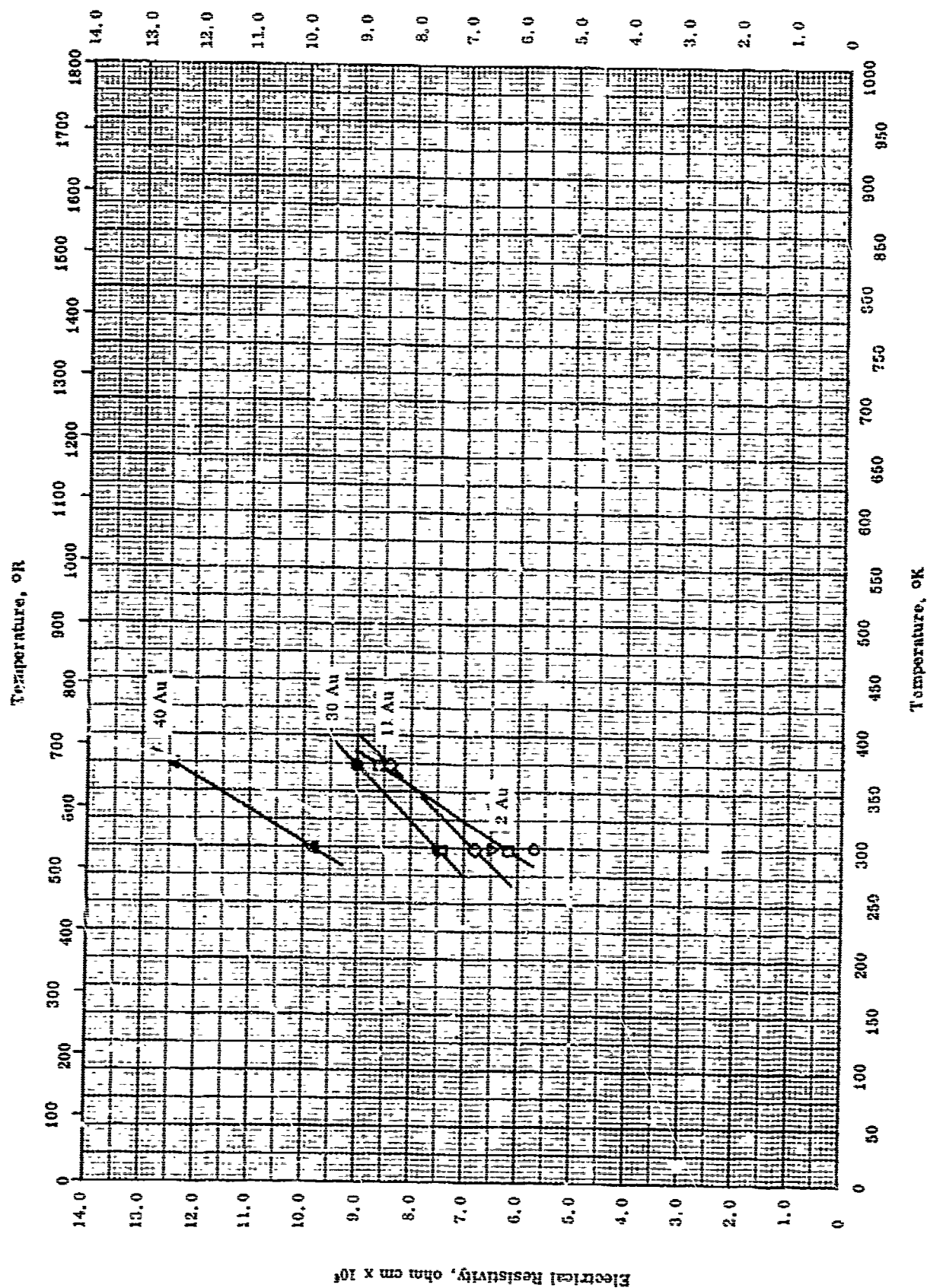
TPRC

THERMAL LINEAR EXPANSION -- CHROMIUM + TUNGSTEN

THERMAL LINEAR EXPANSION -- CHROMIUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---|
| O | 46-2 | 297-1161 | | 65 Cr and 35 W. | Author gives average coeff. of exp. 5.25×10^{-6} per F., 5 to 1630 F. |

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY COBALT + GOLD

TPRC

ELECTRICAL RESISTIVITY -- COBALT + GOLD

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|------------------------------------|
| □ | 55-33 | 298-373 | | 98.0 Co, and 2.0 Au. | Melted from 99.99 Co and 99.99 Au. |
| △ | 56-33 | 298-373 | | 92.5 Co, and 7.5 Au. | Same as above. |
| ◇ | 50-33 | 298-373 | | 89.0 Co, and 11.0 Au. | Same as above. |
| ▽ | 56-33 | 298-373 | | 87.0 Co, and 13.0 Au. | Same as above. |
| ○ | 59-33 | 298-373 | | 85.0 Co, and 15.0 Au. | Same as above. |
| ● | 56-33 | 298-373 | | 70.0 Co, and 30.0 Au. | Same as above. |
| ▲ | 55-33 | 298-373 | | 60.0 Co, and 40.0 Au. | Same as above. |

PROPERTIES OF COBALT + IRON

REPORTED VALUES

Heat of Sublimation

cal g⁻¹Btu lb⁻¹

□ 0.2 Fe

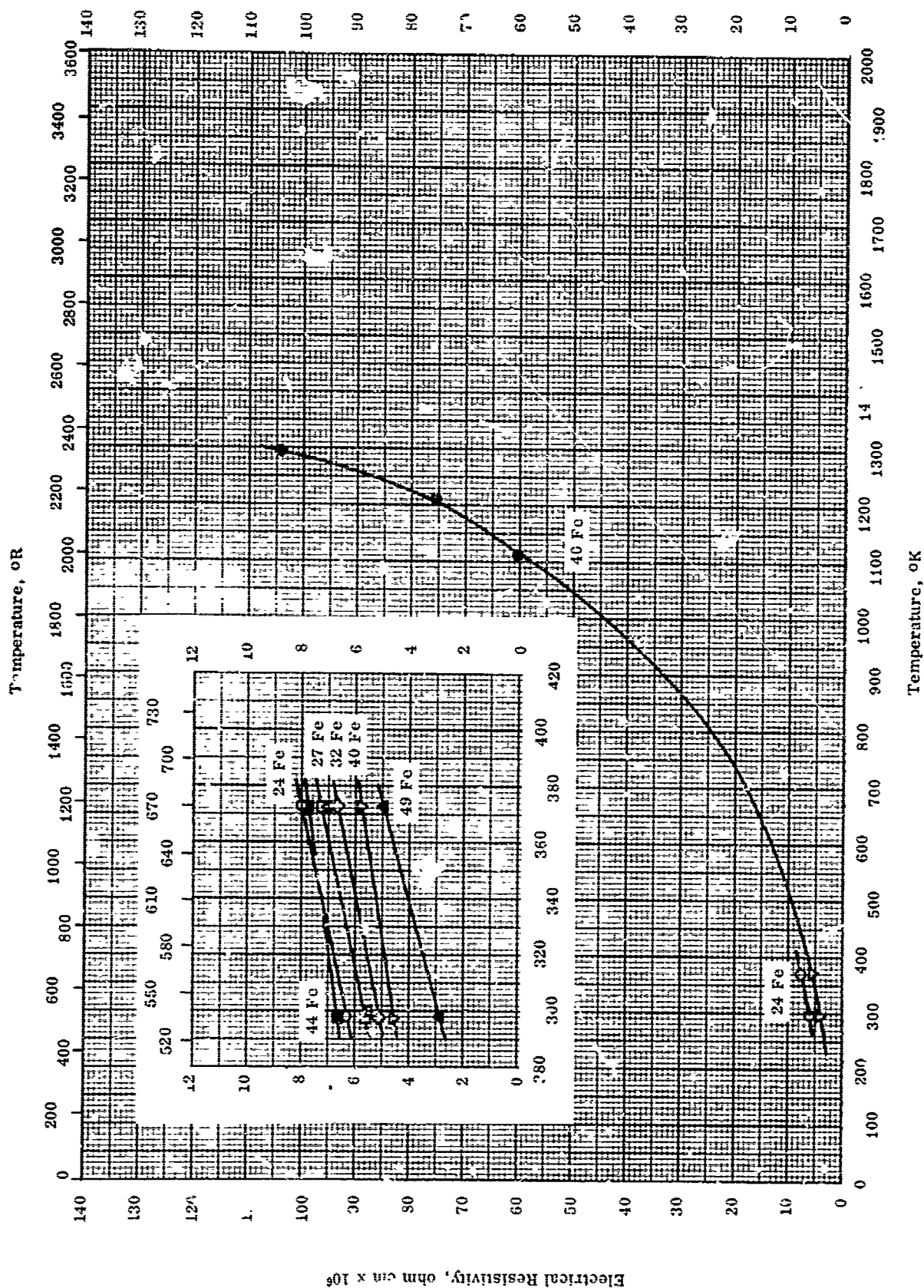
1616
1400 K2910
2500 R

PROPERTIES OF COBALT + IRON

REFERENCE INFORMATION

| Sym Eq | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-----------------------|-------------------|------------------|-------------------------------------|--|
| □ | 54-9 also 55-10 | 2380-2740 | | 99.3 Co, 0.2 Fe, 0.1 Cu, and 0.1 C. | Δh_H from vapor pressure data. |

Electrical Resistivity, ohm cm x 10⁶



ELECTRICAL RESISTIVITY - COBALT + IRON

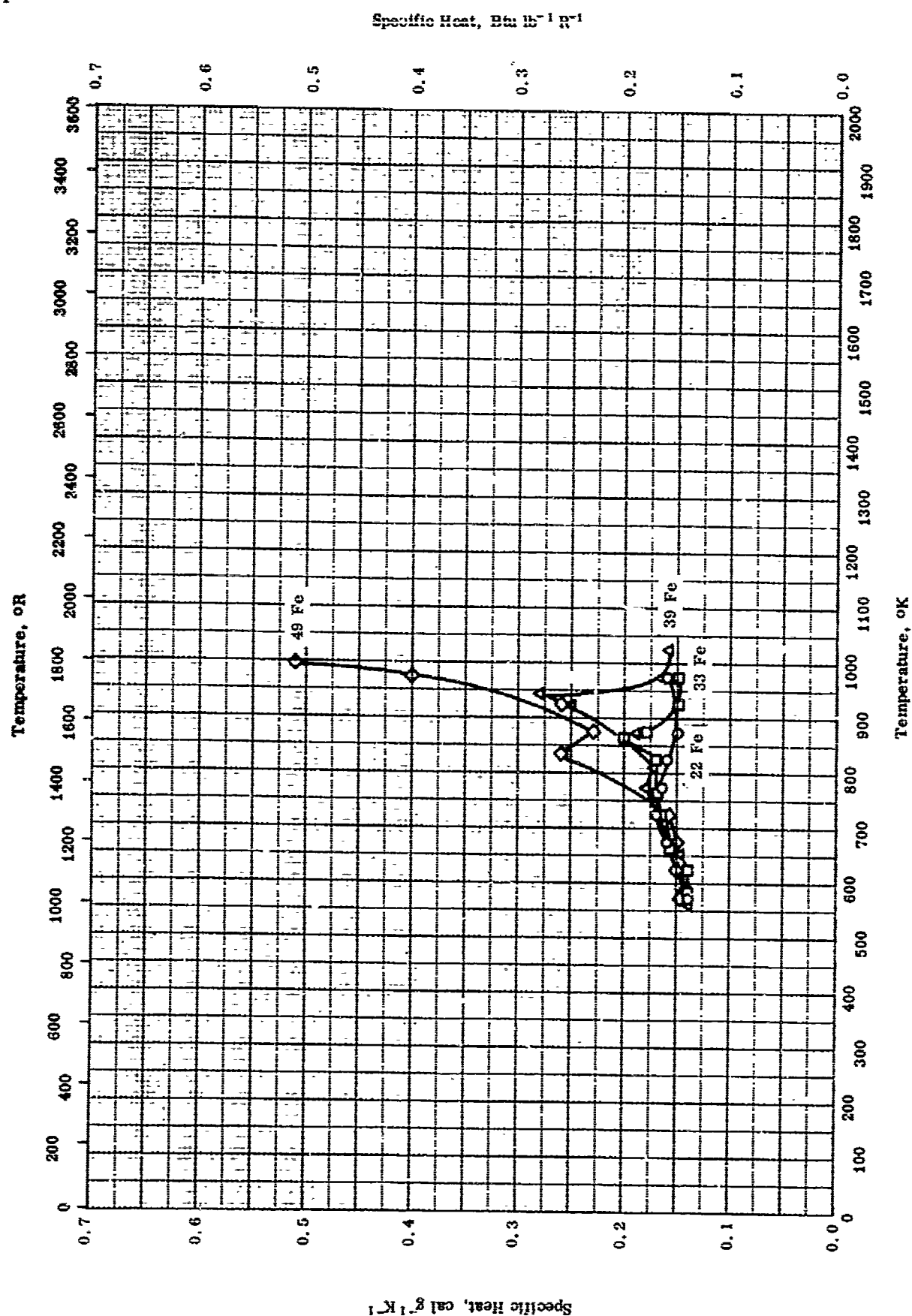
TPRC

ELECTRICAL RESISTIVITY -- COBALT + IRON

REFERENCE INFORMATION

| Sym. Bol. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-------|----------------|---------------|------------------------|-----------------------------------|
| ○ | 57-23 | 298-373 | | 76.10 Co and 23.90 Fe. | Annealed up to 1500 hrs at 500 C. |
| □ | 57-23 | 298-373 | | 73.24 Co and 26.76 Fe. | Same as above. |
| △ | 57-23 | 298-373 | | 71.04 Co and 28.96 Fe. | Same as above. |
| ◇ | 57-23 | 298-373 | | 68.18 Co and 31.82 Fe. | Same as above. |
| ▽ | 57-23 | 298-373 | | 60.22 Co and 39.78 Fe. | Same as above. |
| ● | 48-2 | 1110-1292 | | 60 Co and 40 Fe. | Alloy prepared electrolytically. |
| ■ | 57-23 | 298-373 | | 56.0 Co and 44.0 Fe. | Annealed up to 1500 hrs at 500 C. |
| ▲ | 57-23 | 298-373 | | 51.14 Co and 48.86 Fe. | Same as above. |

TPRC

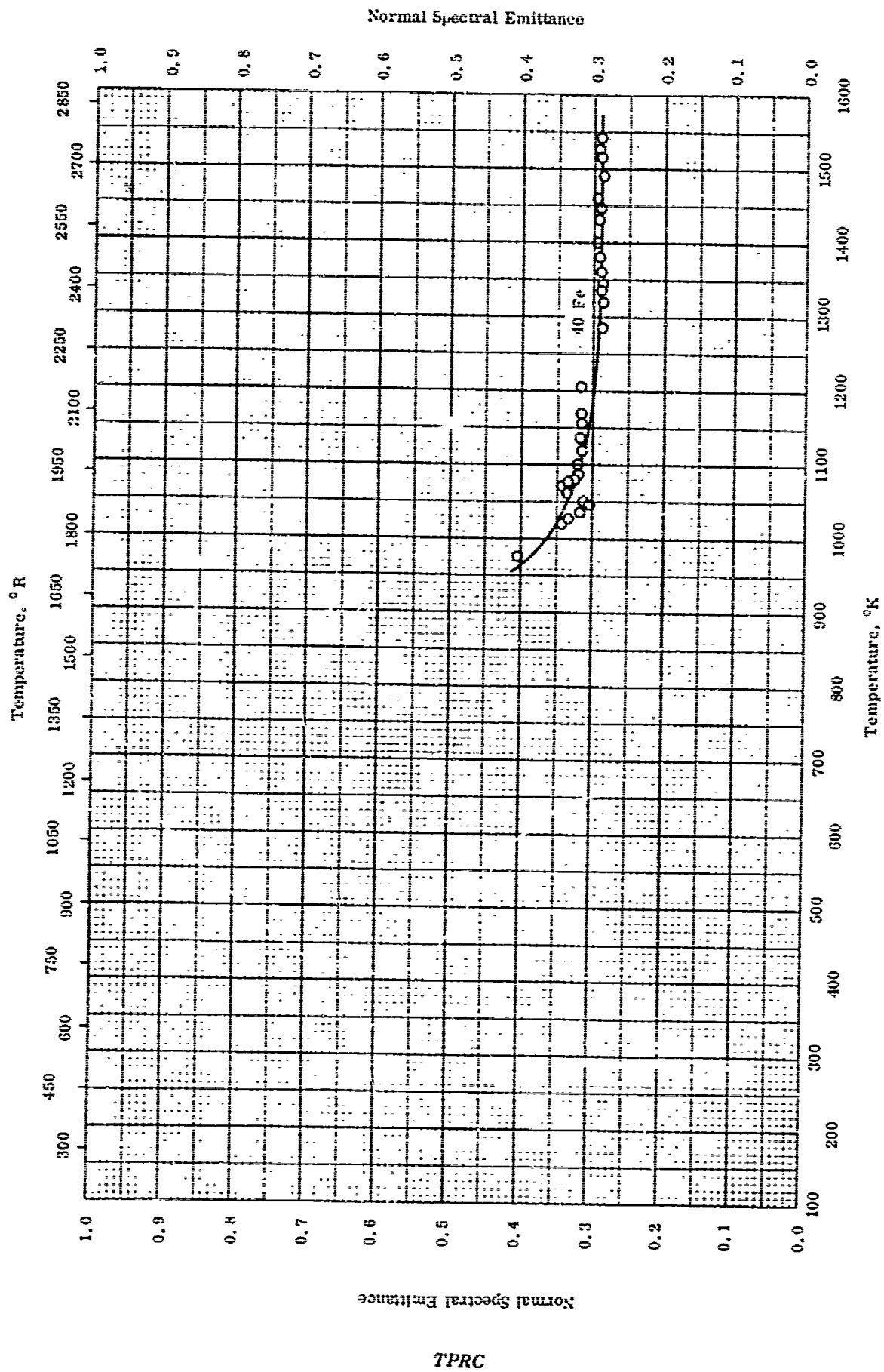


SPECIFIC HEAT -- COBALT + IRON

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 54-11 | 573-973 | | 78 Co and 22 Fe. | Electrolytic Co and Fe; melted in H ₂ ; annealed 2 hrs at 2292 R; cooled to 1248 R at 54 R hr ⁻¹ ; held 10 days at 1248 R; cooled to room tempera- ture at 54 R hr ⁻¹ . |
| □ | 54-11 | 573-973 | | 67.3 Co and 32.7 Fe. | Same as above. |
| △ | 54-11 | 573-973 | | 61 Co and 39 Fe. | Same as above. |
| ◇ | 54-11 | 573-1023 | | 51.4 Co and 48.6 Fe. | Same as above. |

TPRC



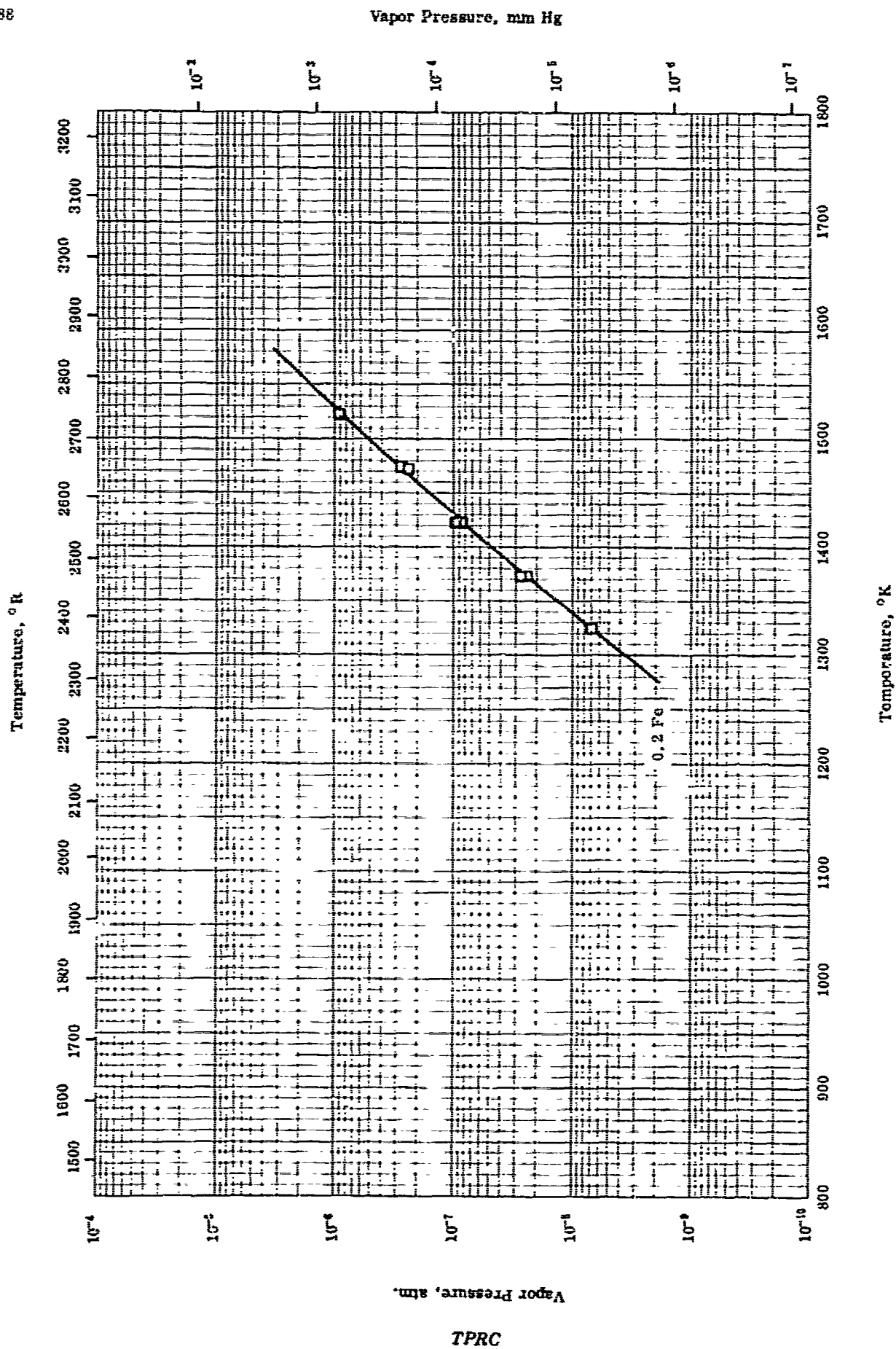
NORMAL SPECTRAL EMITTANCE -- COBALT + IRON

NORMAL SPECTRAL EMITTANCE -- COBALT + IRON

REFERENCE INFORMATION

| Elem No. | Ref. | Wavelength μ | Temp. °K Range | Rept. Error % | Sample Specifications | Remarks |
|-------------|------|---------------------|-------------------|------------------|-----------------------|-----------------------|
| 0 | 48-2 | 0.667 | 975-1540 | | 60 Co and 40 Fe. | Hydrogen surrounding. |

TPRC



VAPOR PRESSURE -- COBALT + IRON

VAPOR PRESSURE -- COBALT + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|--------------------------|-----------------------|-------------------|------------------|------------------------------|--|
| <input type="checkbox"/> | 54-9 also 55-10 | 1322-1523 | | 99.3 Co, 0.2 Fe, and 0.1 Cu. | Ref. 54-56 lists an additional 0.1 C in the composition. |

TPRC

PROPERTIES OF COBALT + NICKEL

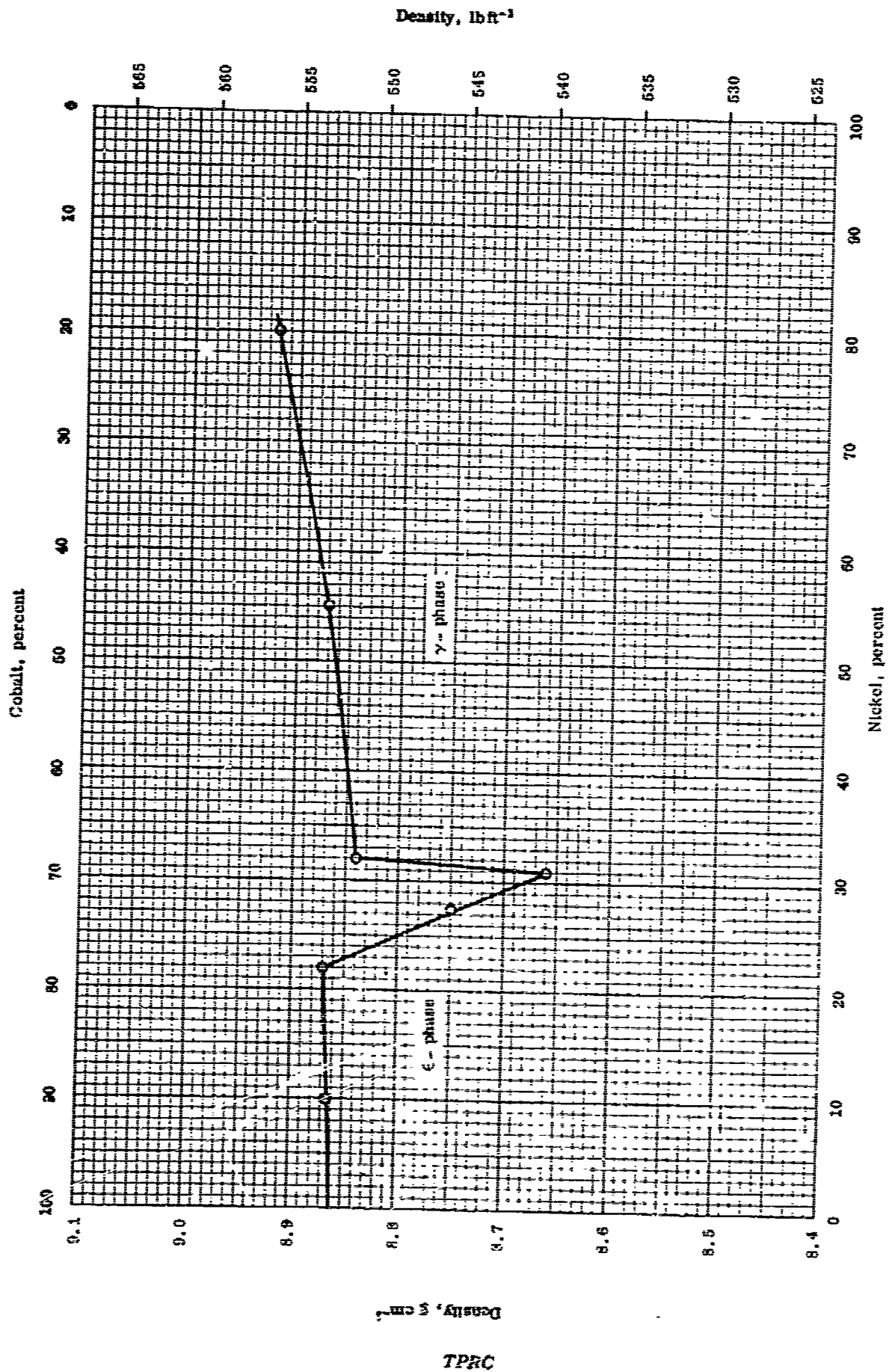
REPORTED VALUES

| | | |
|----------------------|---------------------|----------------------|
| Density: | See figure | |
| Heat of Sublimation: | cal g ⁻¹ | Btu lb ⁻¹ |
| Δ 0.05-0.5 Ni | 1724.4 | 3193.9 |

PROPERTIES OF COBALT + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---|
| Δ | 51-8 | 0 | | 99.25 Co, 0.05 - 0.5 Ni, 0.01 - 0.1 Fe 0.005 - 0.05 each Si, Cu and Mn, 0.001 - 0.01 Al, and 0.001 - Ca. | Δh _N from vapor pressure data. |



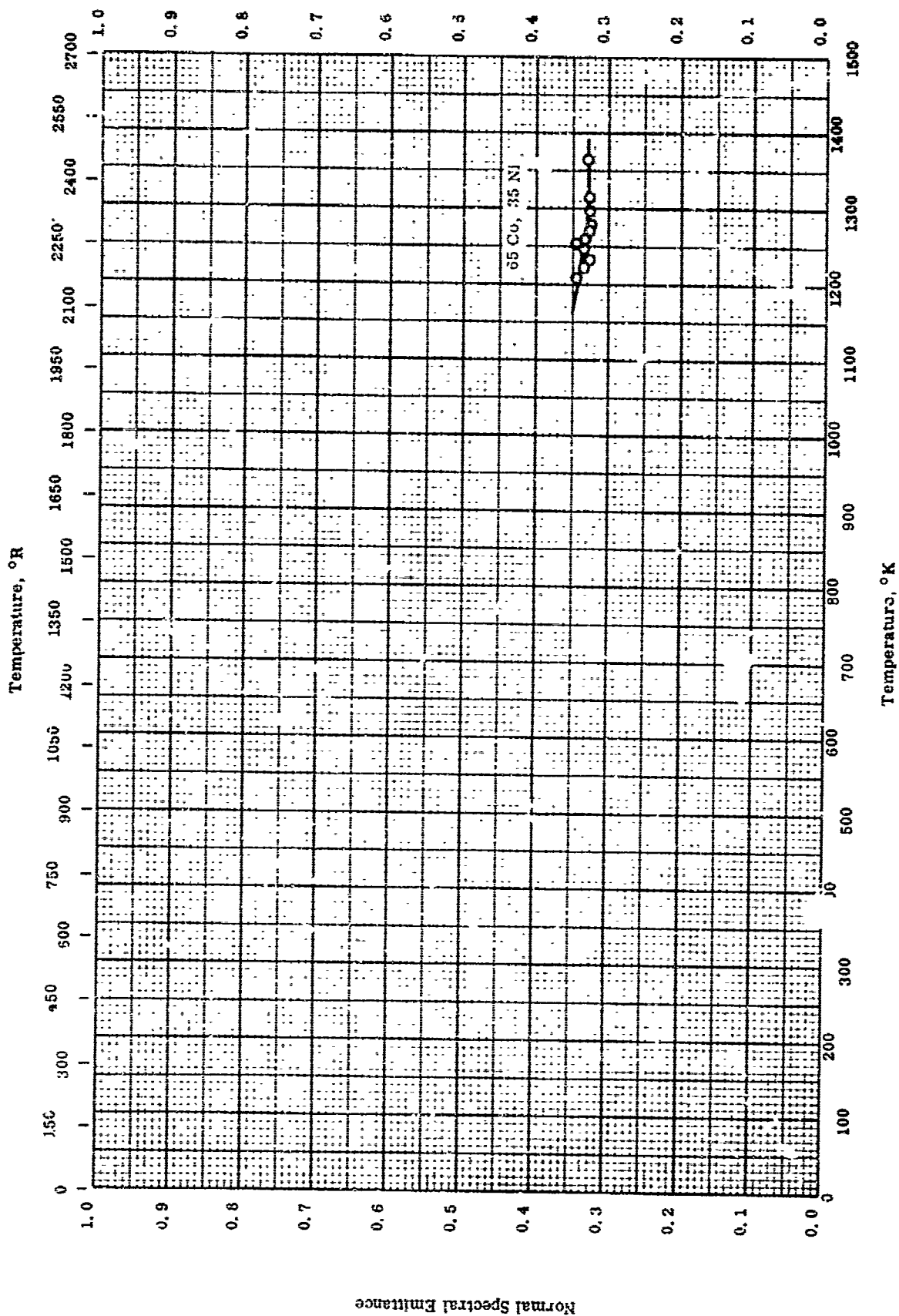
DENSITY -- COBALT + NICKEL

DENSITY --- COBALT + NICKEL

REFERENCE INFORMATION

| Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------|----------------|---------------|--|--|
| 50-12 | 208 | | 10-32 Ni ; made from 99.92 pure electrolytic Ni (0.037 Fe, 0.030 Co, 0.023 As, 0.020 Cu, 0.01 C, 0.005 P, 0.001 Si, and 0.001 Mn), and 99.87 pure electrolytic Co (0.117 Fe, 0.06 C, 0.02 As, 0.04 Cu, 0.013 P, 0.091 Si, and 0.001 Mn). | Melted in aluminum tube, forged, annealed, rolled, annealed, machined to size, and annealed 2 hrs at 1100 C. |

Normal Spectral Emittance



NORMAL SPECTRAL EMITTANCE -- COBALT + NICKEL

TPRC

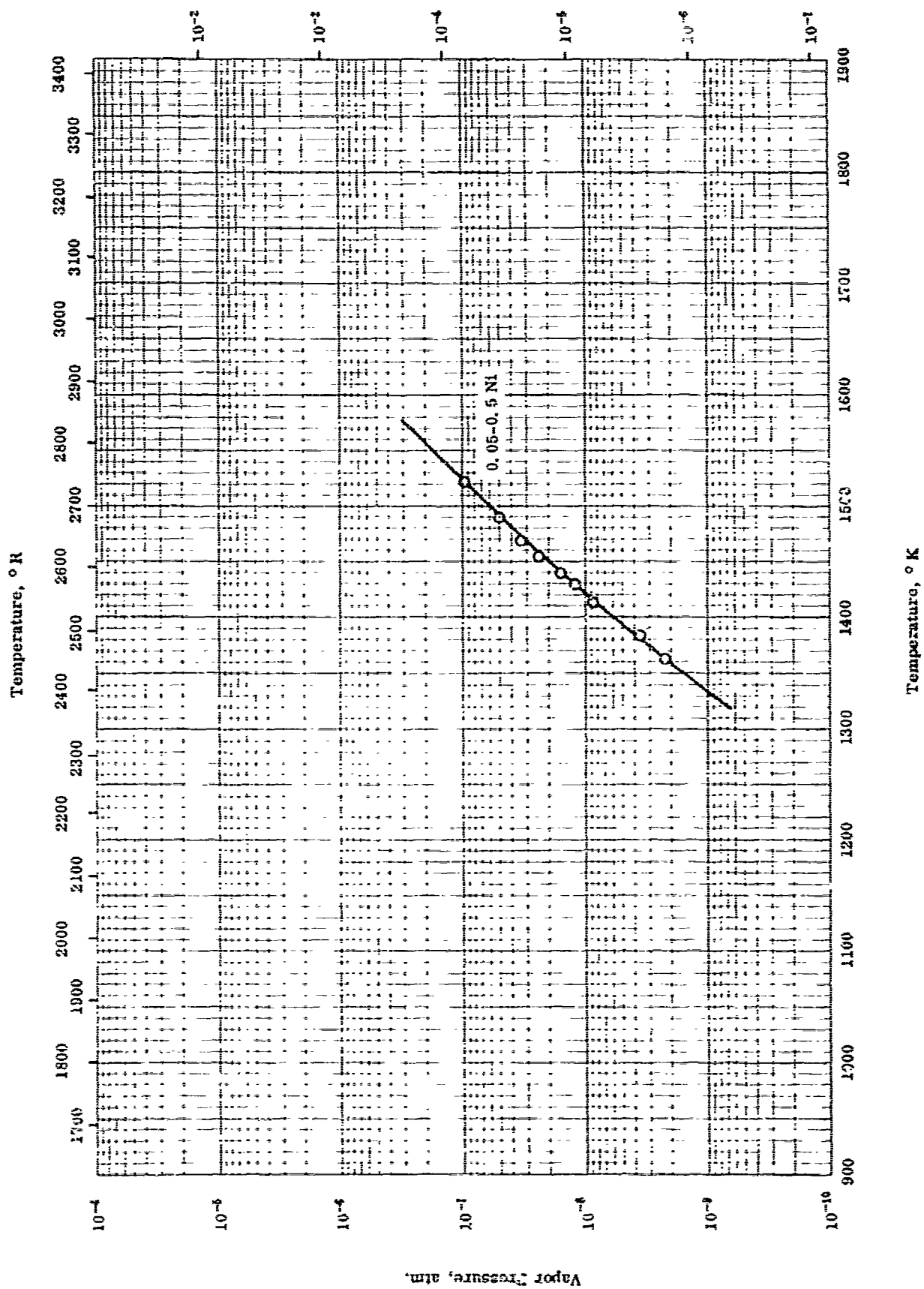
NORMAL SPECTRAL EMITTANCE -- COPALIT + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|------|---------------------|--------------------|-------------------|--|---------|
| O | 48-6 | 0.667 | 1210-1366 | | 65 Co and 35 Ni; manufactured by International Nickel Lab. | |

TPRC

Vapor Pressure, mm Hg



VAPOR PRESSURE -- COBALT + NICKEL

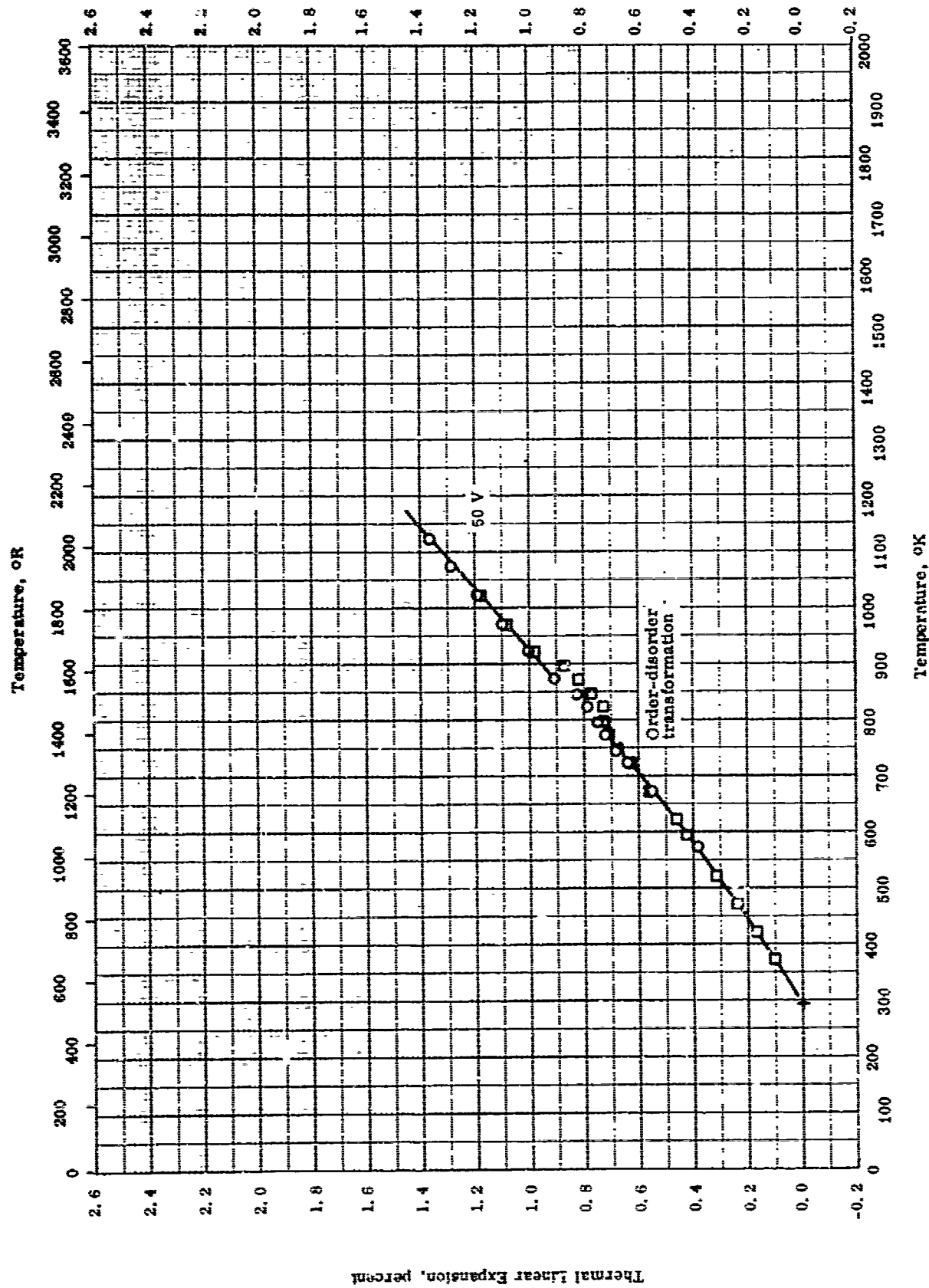
VAPOR PRESSURE -- COBALT + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---------|
| O | 51-8 | 1414-1523 | | 99.25 Co, 0.05-0.5 Ni, 0.01-0.1 Fe, 0.005-0.05 ea Si, Cu, Mn, 0.001-0.01 Al, <0.001 Ca, and Mo not detected. | |

TPRC

Thermal Linear Expansion, percent



THERMAL LINEAR EXPANSION -- COBALT + VANADIUM

TPRC

THERMAL LINEAR EXPANSION -- COBALT + VANADIUM

REFERENCE INFORMATION

| Sam bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---|
| ○ | 64-8 | 293-1123 | | 50,004 Co and 49,996 V; dimension 50 mm by 4 mm by 4 mm. | Prepared by vacuum melting in zirconia molds in an induction furnace. |
| □ | 64-8 | 293-1073 | | Same as above. | Same as above except quenched at 800 C. |

TPRC

PROPERTIES OF COPPER + ALUMINUM

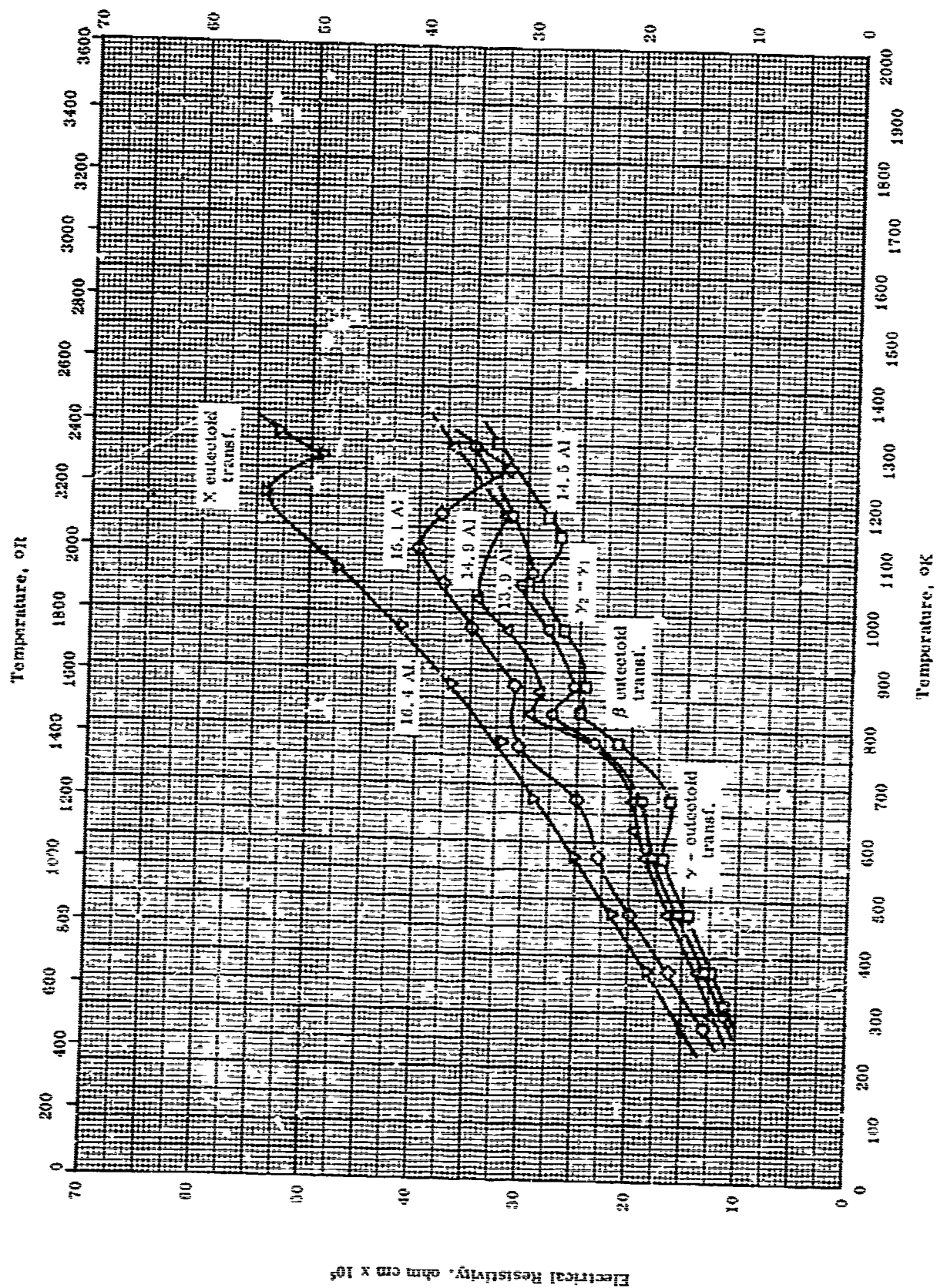
REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| ○ 11.95 | 7.28 | 455 |

PROPERTIES OF COPPER + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 53-24 | 298 | | 11.95 Al | |

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- COPPER + ALUMINUM

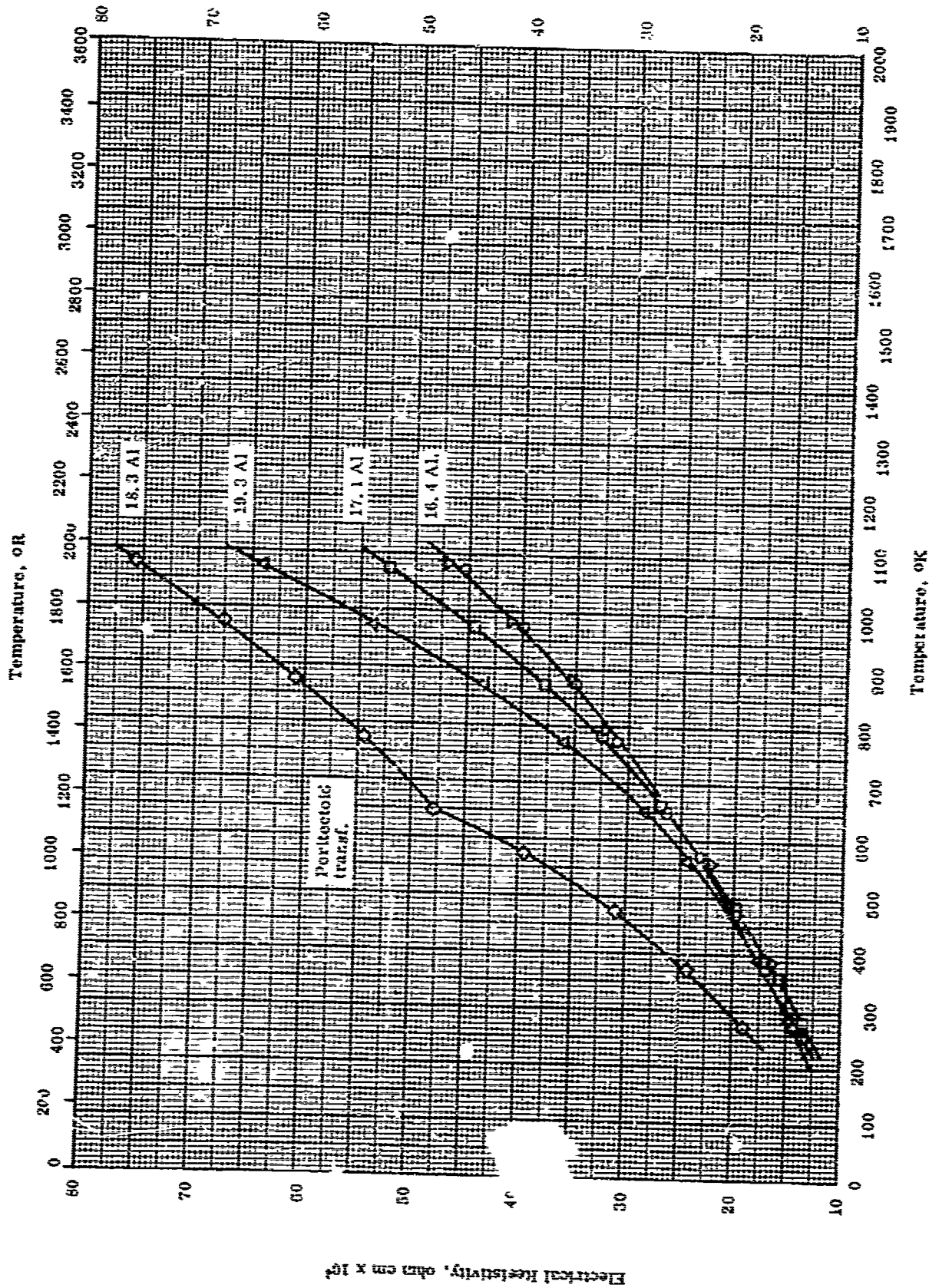
TPRC

ELECTRICAL RESISTIVITY -- COPPER + ALUMINUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °C | Rept. Error % | Sample Specification # | Remarks |
|------------|-------|-------------------|------------------|------------------------|---------|
| ○ | 67-22 | 298-1203 | | 13, 9 Al. | |
| □ | 67-22 | 313-1303 | | 14, 6 Al. | |
| △ | 67-22 | 298-1203 | | 14, 9 Al. | |
| ◇ | 67-22 | 273-1203 | | 15, 15 Al. | |
| ▽ | 67-22 | 273-1313 | | 16, 4 Al. | |

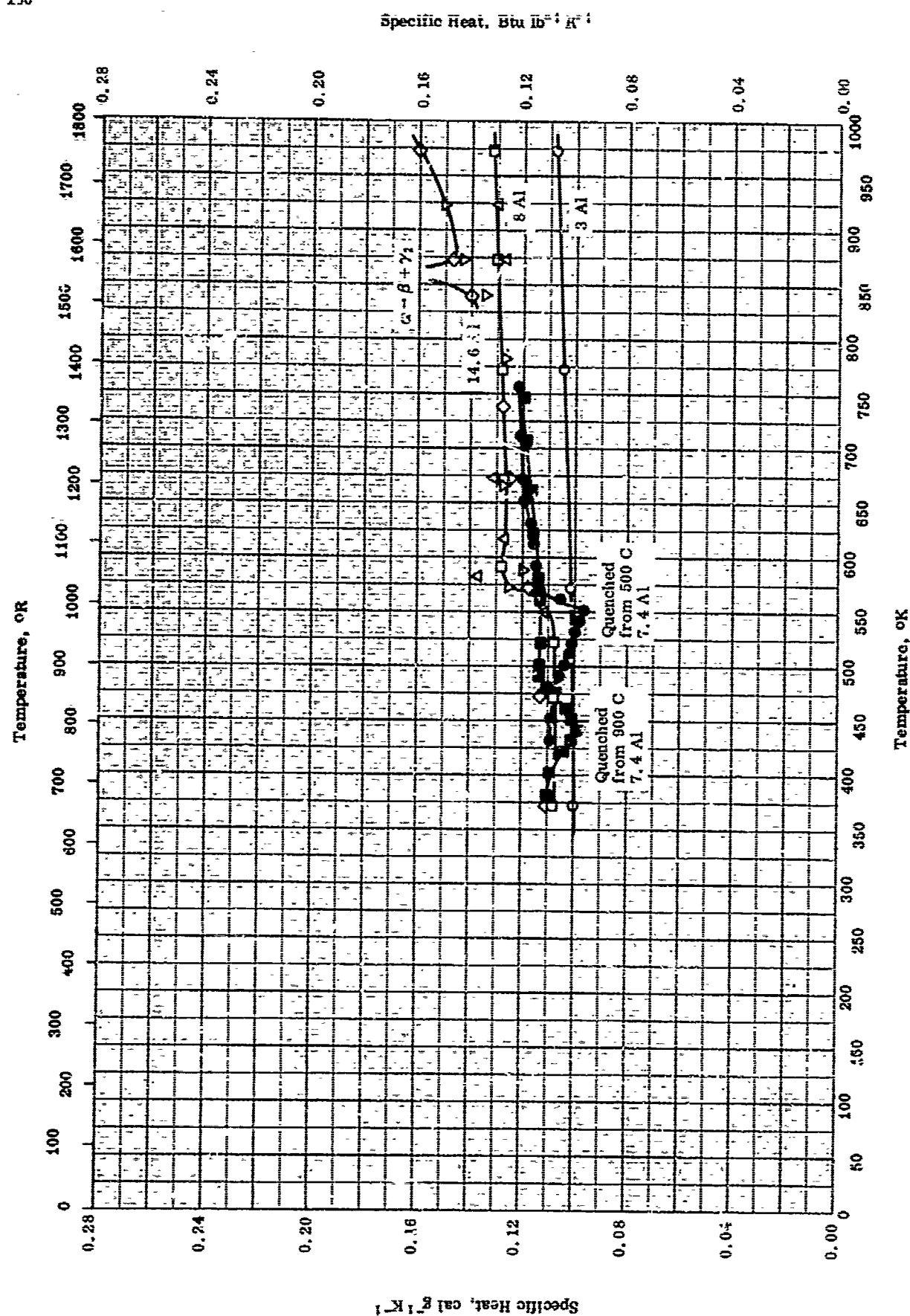
TPRC

Electrical Resistivity, ohm cm $\times 10^6$ ELECTRICAL RESISTIVITY --- COPPER + ALUMINUM
(in γ_2 phase)

ELECTRICAL RESISTIVITY -- COPPER + ALUMINUM
(In γ_2 phase)

REFERENCE INFORMATION

| Spec. Bol. | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-----------------|---------------|--------------------------------|---------|
| ○ | 57-28 | 273-1073 | | 16.41 Al; in γ_2 phase. | |
| □ | 57-28 | 273-1073 | | 17.08 Al; same as above. | |
| ▽ | 57-28 | 273-1073 | | 17.40 Al; same as above. | |
| ◇ | 57-26 | 273-1073 | | 18.30 Al; same as above. | |
| △ | 57-28 | 273-1073 | | 19.30 Al; same as above. | |



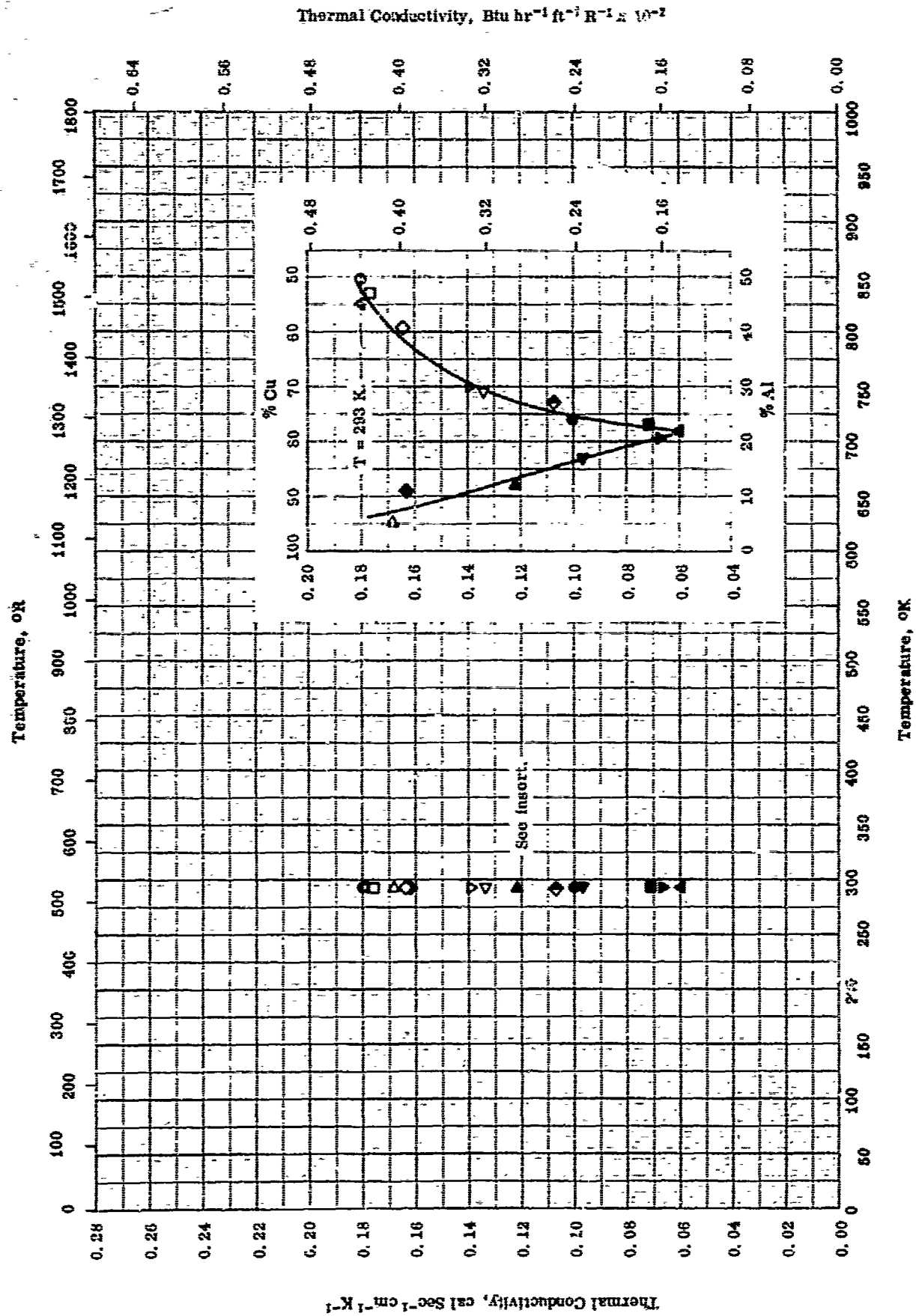
SPECIFIC HEAT -- COPPER + ALUMINUM

SPECIFIC HEAT -- COPPER + ALUMINUM

REFERENCE INFORMATION

| Sym Dot | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 54-12 | 373-973 | | 96.87 Cu and 3.13 Al; prepared from Cu containing 0.02 S, Zn, 0.01 Ag, Pb and Sb; and Al containing 0.42 Si, 0.14 Fe, 0.04 Zn, 0.005 Cu, 0.001 S, trace Mn. | Annealed 1 hr at 700 C in vacuum, cooled at 30 C hr ⁻¹ to room temperature, reheated for 3-1/2 to 10 hrs at 550 C and cooled slowly. |
| □ | 54-12 | 373-973 | | 91.95 Cu and 8.05 Al; raw materials same as above. | Same as above. |
| △ | 54-12 | 373-973 | | Same as above | Same as above; baked 220 hrs at 210 C. |
| ◇ | 54-12 | 373-973 | | 85.41 Cu and 14.59 Al; raw materials same as above. | Annealed 1 hr at 700 C in vacuum; cooled at 30 C hr ⁻¹ to room temperature; reheated 3-1/2 to 10 hrs at 550 C, cooled slowly. |
| ▽ | 54-12 | 373-973 | | Same as above. | Same as above. |
| ● | 59-10 | 373-773 | 0.8 | 92.6 Cu and 7.4 Al. | Quenched from 500 C. |
| ■ | 59-10 | 373-773 | 0.8 | 92.6 Cu and 7.4 Al. | Quenched from 900 C. |

TPRC



THERMAL CONDUCTIVITY -- COPPER + ALUMINUM

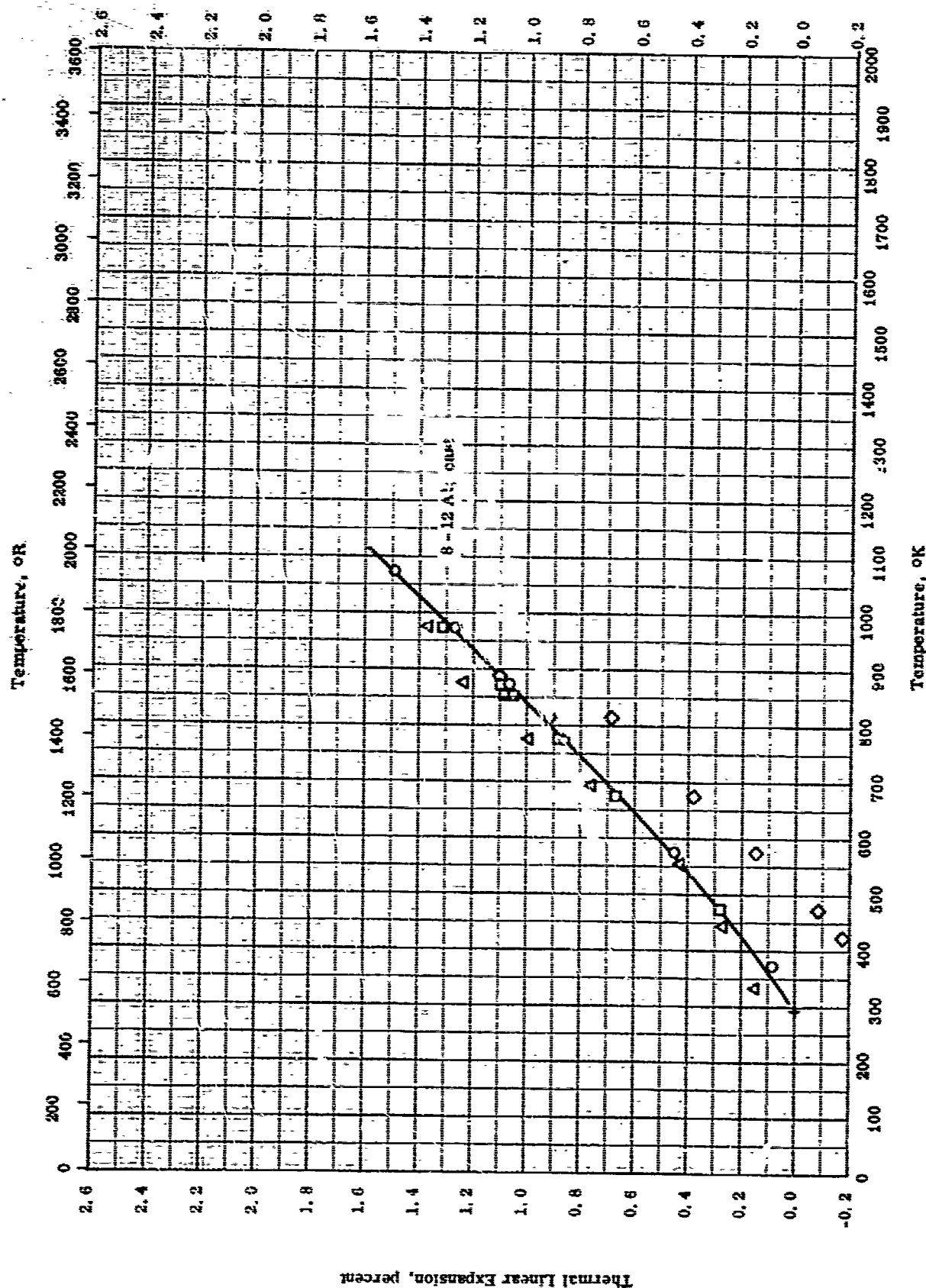
THERMAL CONDUCTIVITY -- COPPER + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| ○ | 56-4 | 298 | | 50.45 Cu, 49.55 Al; raw materials electrolytically pure. | Annealed 5 hrs near melting point, and furnace cooled. |
| □ | 56-4 | 298 | | 53.00 Cu, 47.00 Al; raw materials same as above. | Same as above. |
| △ | 56-4 | 298 | | 55.00 Cu, 45.00 Al; raw materials same as above. | Same as above. |
| ◇ | 56-4 | 298 | | 59.02 Cu, 40.98 Al; raw materials same as above. | Same as above. |
| ▽ | 56-4 | 298 | | 69.00 Cu, 30.01 Al; raw materials same as above. | Same as above. |
| ▽ | 56-4 | 298 | | 71.00 Cu, 29.00 Al; raw material same as above. | Same as above. |
| ◆ | 56-4 | 298 | | 73.00 Cu, 27.00 Al; raw materials same as above. | Same as above. |
| ● | 56-4 | 298 | | 76.00 Cu, 24.00 Al; raw materials same as above. | Same as above. |
| ■ | 56-4 | 298 | | 77.00 Cu, 23.00 Al; raw materials same as above. | Same as above. |
| ▲ | 56-4 | 298 | | 78.00 Cu, 22.00 Al; raw materials same as above. | Same as above. |
| ▼ | 56-4 | 298 | | 79.58 Cu, 20.42 Al; raw materials same as above. | Same as above. |
| ▼ | 56-4 | 298 | | 82.00 Cu, 17.00 Al; raw materials same as above. | Same as above. |
| ▲ | 56-4 | 298 | | 88.00 Cu, 12.00 Al; raw materials same as above. | Same as above. |
| ◆ | 56-4 | 298 | | 89.22 Cu, 10.78 Al; raw materials same as above. | Same as above. |
| △ | 56-4 | 298 | | 95.00 Cu, 5.00 Al; raw materials same as above. | Same as above. |

TPRC

Thermal Linear Expansion, percent



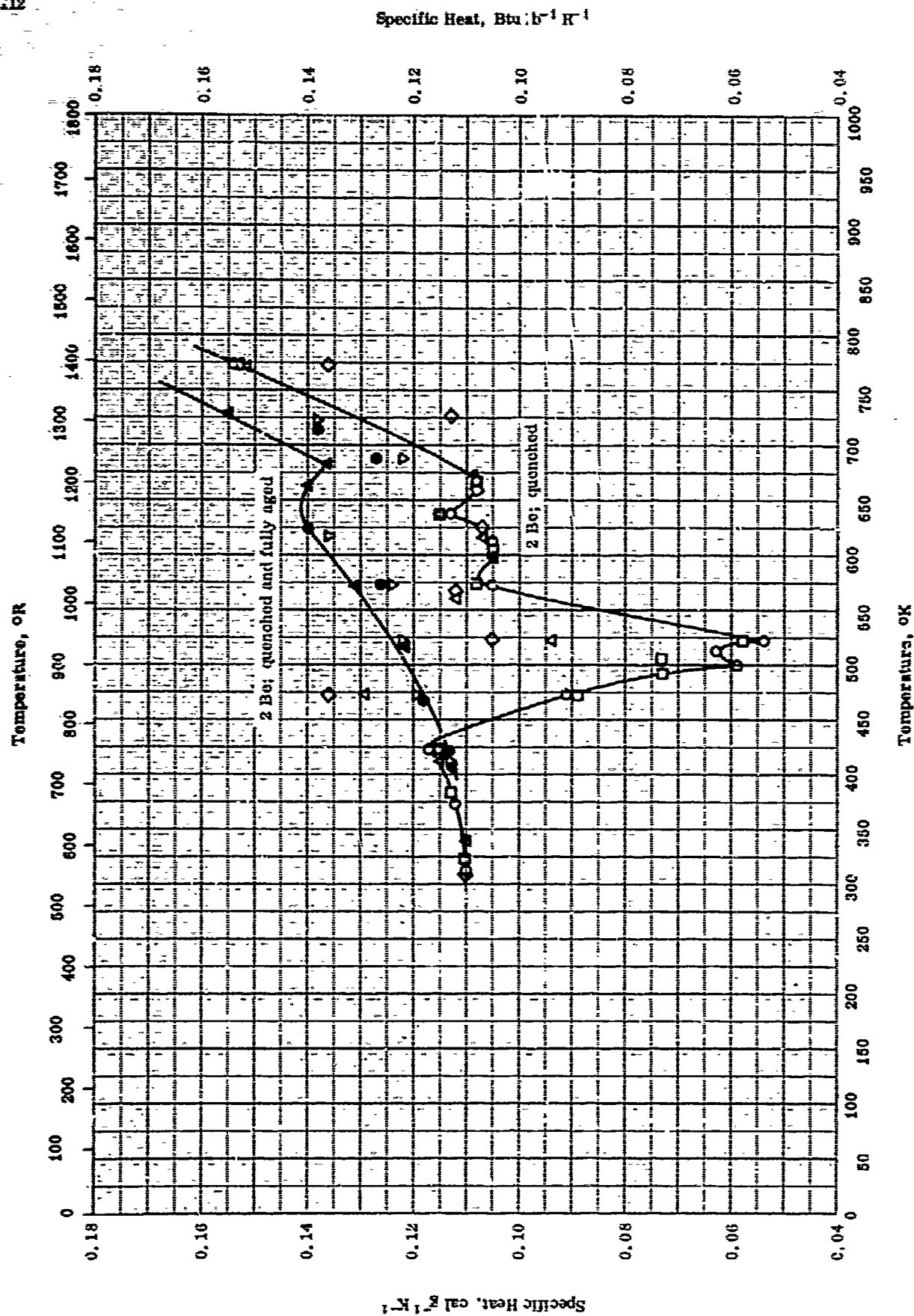
THERMAL LINEAR EXPANSION -- COPPER + ALUMINUM

TPRC

THERMAL LINEAR EXPANSION --- COPPER + ALUMINUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|---|--|
| ○ | 43-7 | 293-1073 | | 91.49 Cu by diff., 8.40 Al, and 0.06 impurities. | Cast, heated at 950 C for 12 hrs, and cooled to room temperature in 400 hrs; tested at 1 C min ⁻¹ . |
| □ | 43-7 | 293-973 | | 87.98 Cu by diff., 11.00 Al, and 0.06 impurities. | Same as above. |
| △ | 53-24 | 293-973 | | 11.05 Al. | Heating rate 4 C min ⁻¹ . |
| ◇ | 53-24 | 432-973 | | Same as above. | Cooling data of above specimen with cooling rate 0.3 C min ⁻¹ . |

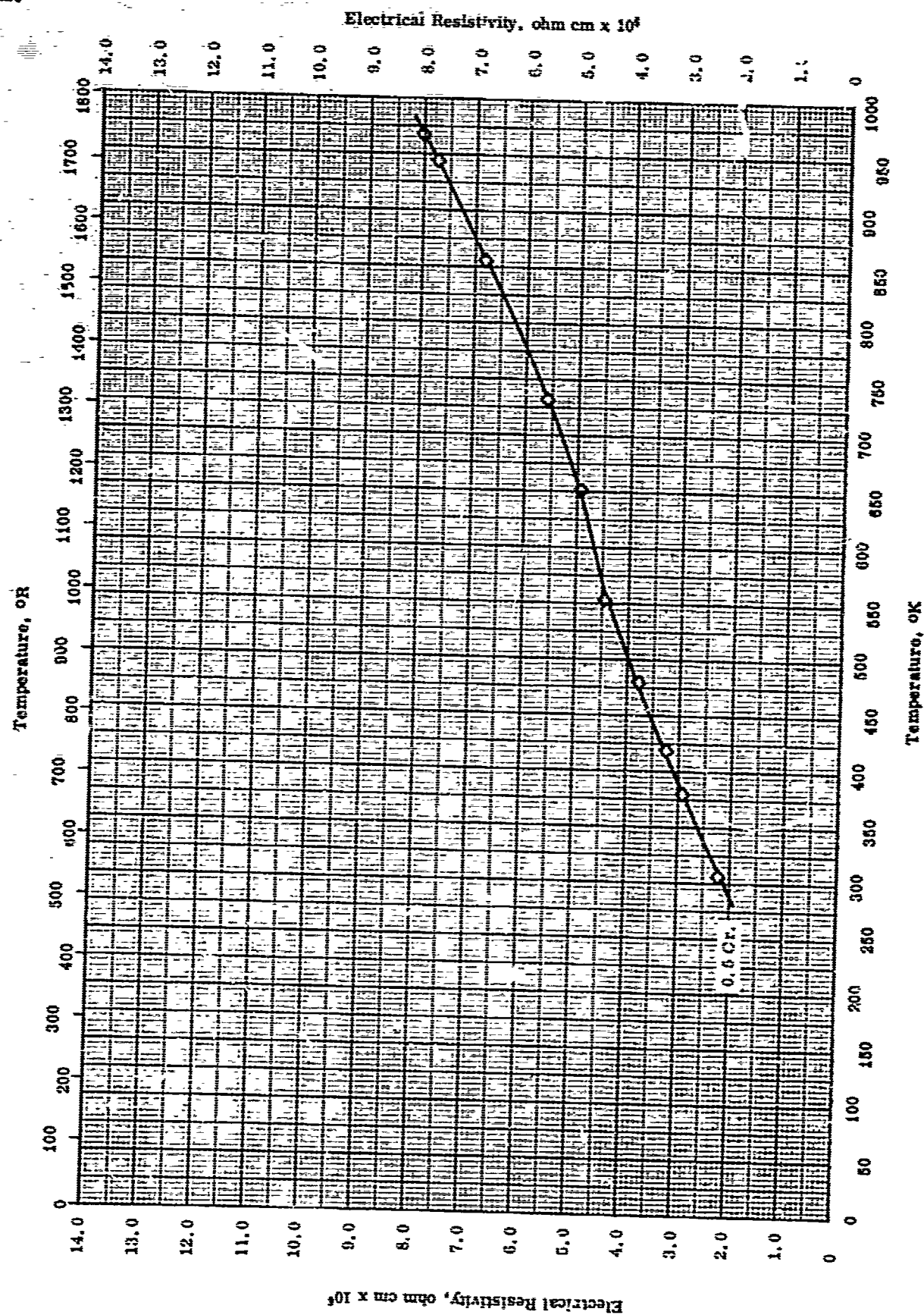


SPECIFIC HEAT -- COPPER + BERYLLIUM

SPECIFIC HEAT -- COPPER + BERYLLIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 55-13 | 373-873 | | 1.8 Be. | Heated 4 hrs at 800 C and quenched. |
| □ | 55-13 | 373-873 | | 1.8 Be. | Heated 4 hrs at 800 C and quenched; aged 13 hrs at 130 C. |
| △ | 55-13 | 373-873 | | 1.8 Be. | Heated 4 hrs at 800 C and quenched; aged 90 hrs at 130 C. |
| ◇ | 55-13 | 373-873 | | 1.8 Be | Heat 4 hrs at 800 C and quenched; aged 700 hrs at 130 C. |
| ▽ | 55-13 | 373-873 | | 1.8 Be. | Heated 4 hrs at 800 C and quenched; aged 1 hr at 300 C. |
| ● | 55-13 | 373-873 | | 1.8 Be. | Heated 4 hrs at 800 C and quenched; aged 45 hrs at 300 C. |
| ▲ | 55-13 | 373-873 | | 1.8 Be. | Heated 4 hrs at 800 C and quenched; aged 254 hrs at 300 C. |

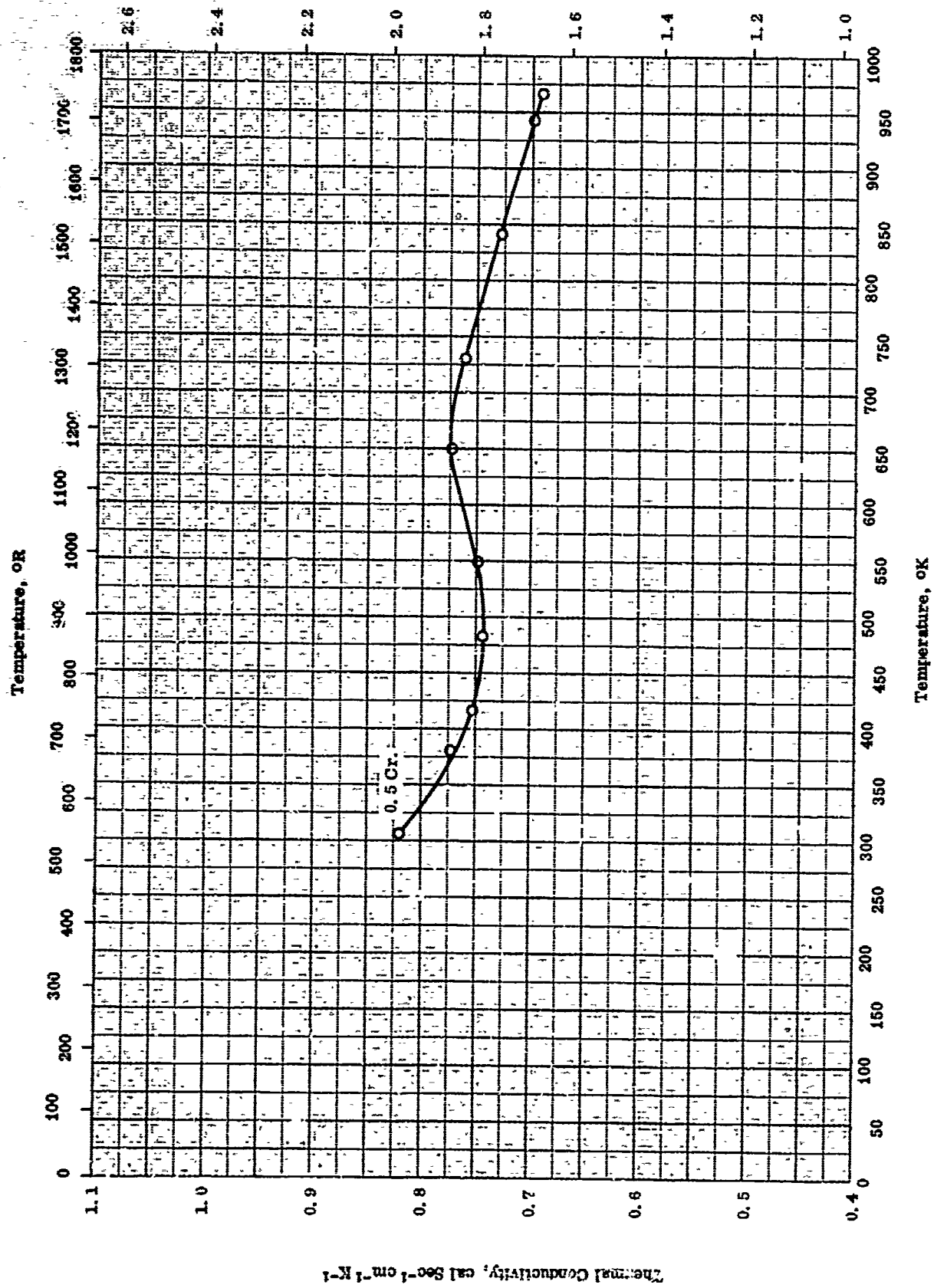


ELECTRICAL RESISTIVITY -- COPPER + CHROMIUM

ELECTRICAL RESISTIVITY -- COPPER + CHROMIUM

REFERENCE INFORMATION

| Sym Eol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|-------------|
| ◇ | EG-6 | 300-907 | | 0.5 Gr. | Normalized. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-3}$ 

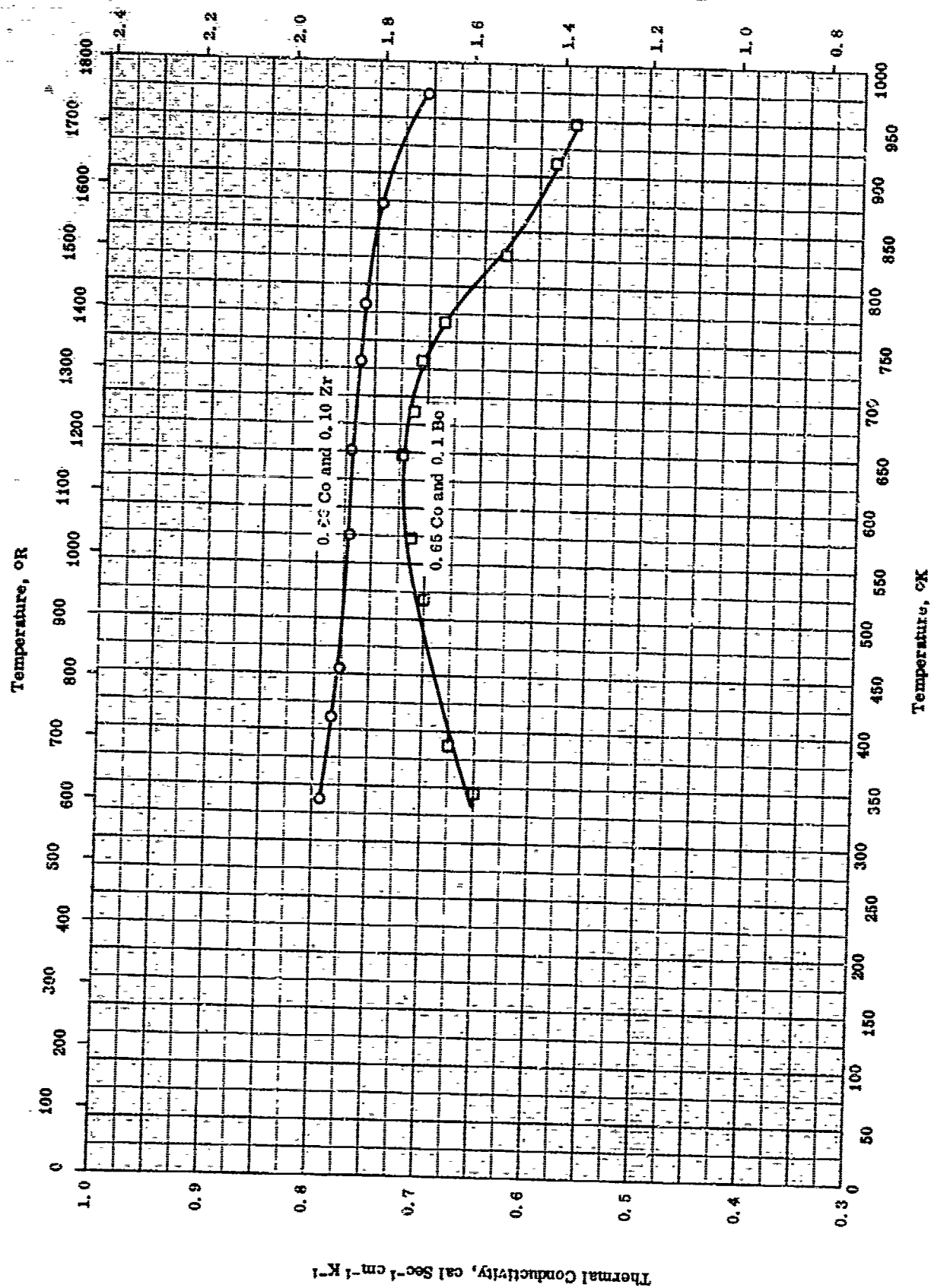
THERMAL CONDUCTIVITY -- COPPER + CHROMIUM

TPRC

THERMAL CONDUCTIVITY -- COPPER + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|-------------|
| O | 56-6 | 306-967 | | 0.5 Cr. | Normalized. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$ 

THERMAL CONDUCTIVITY -- COPPER + COBALT

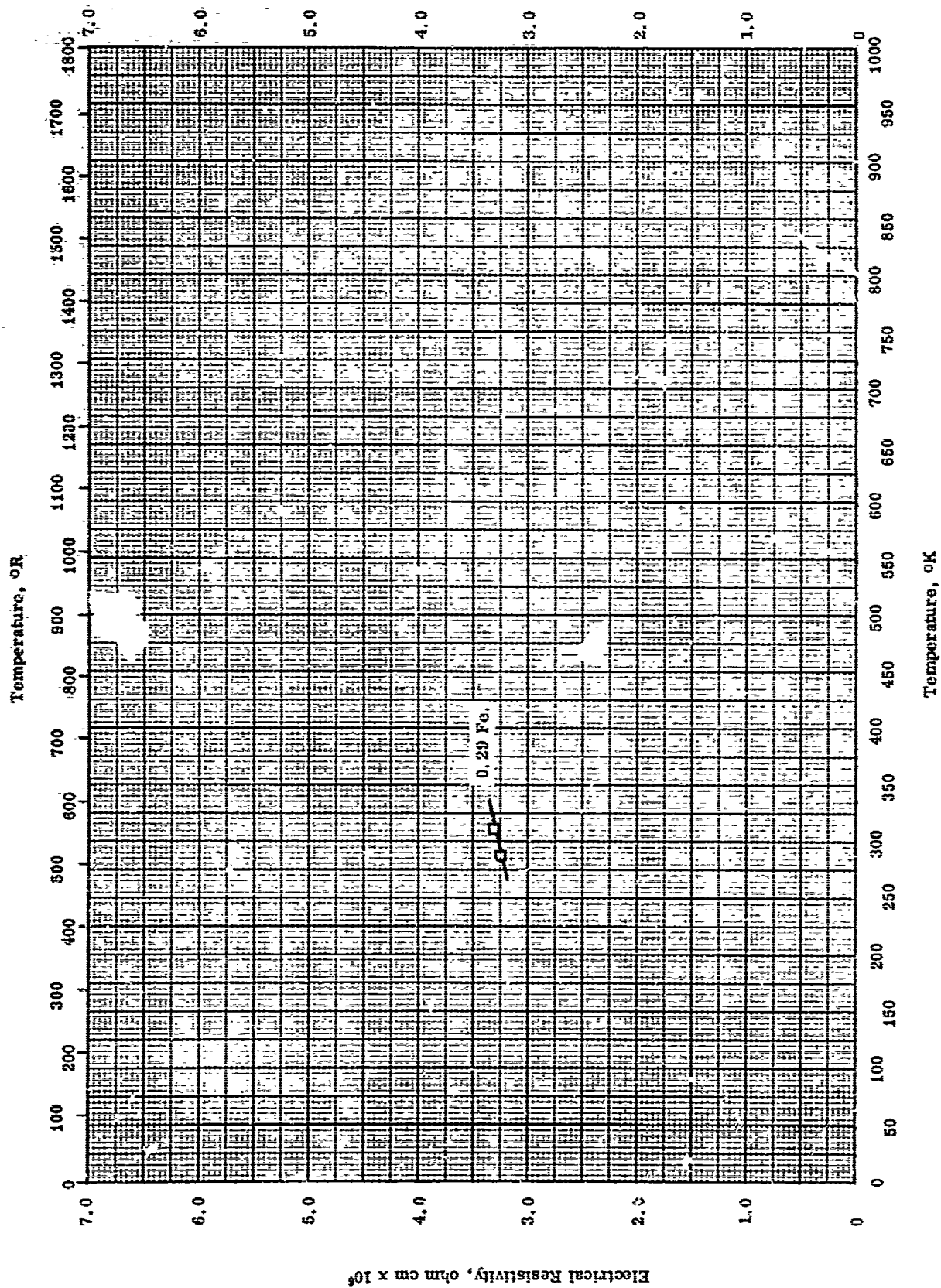
TPRC

THERMAL CONDUCTIVITY -- COPPER + COBALT

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---------|
| ○ | 57-2 | 337-873 | | 99.23 Cu, 0.60 Co, 0.10 Zr, and 0.03 F. | |
| □ | 59-1 | 345-848 | | 99.25 Cu, 0.65 Co, and 0.1 Be. | |

TPRC

Electrical Resistivity, ohm cm x 10⁶

TPRC

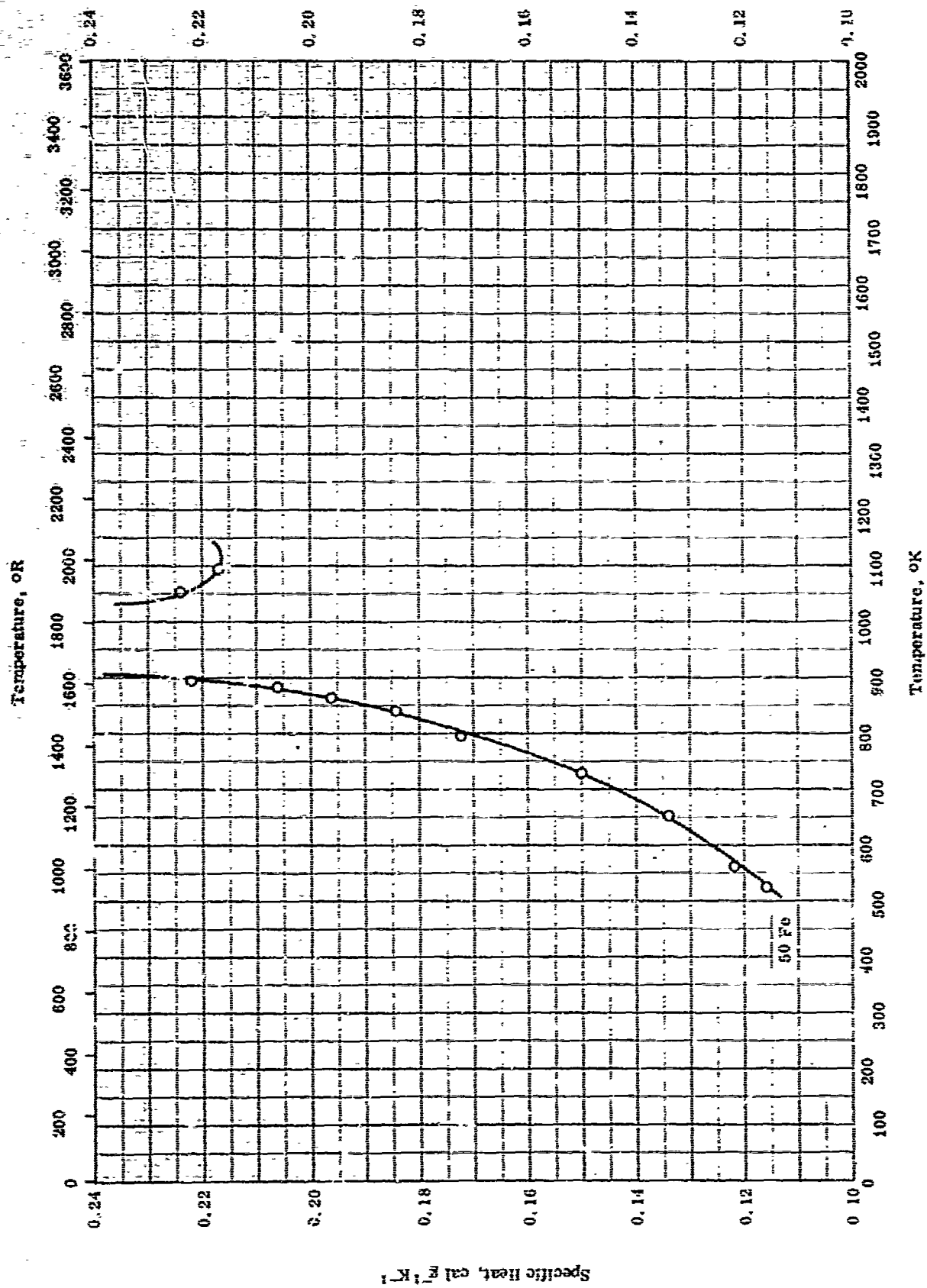
ELECTRICAL RESISTIVITY -- COPPER + IRON

ELECTRICAL RESISTIVITY -- COPPER + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---------|
| □ | 56-32 | 288-313 | | 0.291 Fe, 0.008 > Mg, 0.004 > Si, 0.001 > each of others. | |

TPRC

Specific Heat, Btu lb⁻¹ R⁻¹

SPECIFIC HEAT -- COPPER + IRON

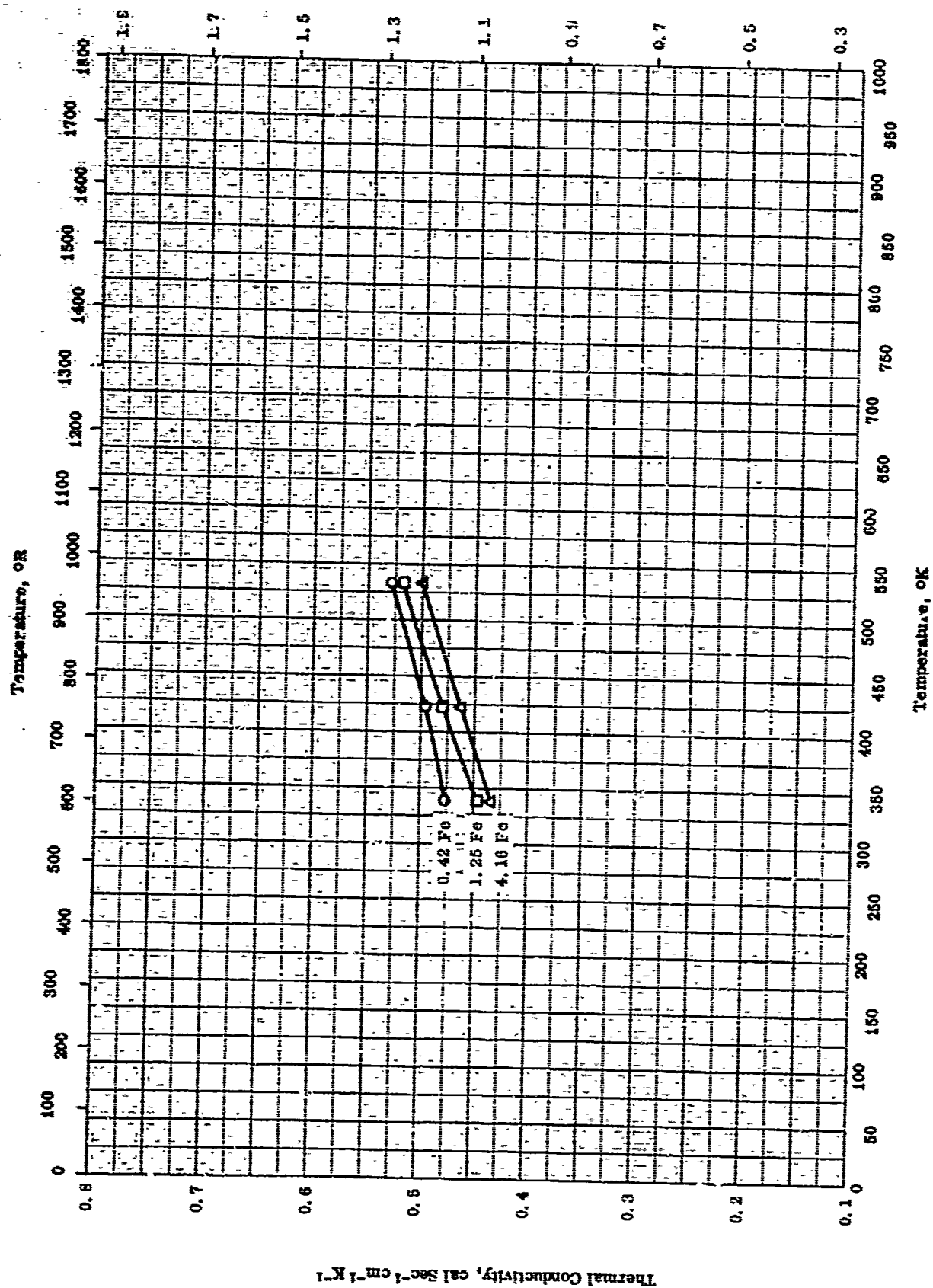
TPRC

SPECIFIC HEAT -- COPPER + IRON

REFERENCE INFORMATION

| Sym Bot | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 55-14 | 528-1095 | ±5.0 | 50 Cu. | |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-3}$ 

THERMAL CONDUCTIVITY -- COPPER + IRON

TPRC

THERMAL CONDUCTIVITY --- COPPER + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-------------------------------------|--|
| ○ | 51-1 | 329-532 | ±5 | 0.42 ± 0.03 Fe and 0.012 ± 0.001 P. | Prepared from electrolytic tough pitch copper. |
| □ | 52-1 | 339-533 | ±5 | 1.25 Fe, and 0.014 P. | Same as above. |
| △ | 53-1 | 337-533 | ±5 | 4.16 ± 0.02 Fe and 0.018 P. | Same as above. |

TPRC

PROPERTIES OF COPPER + LEAD

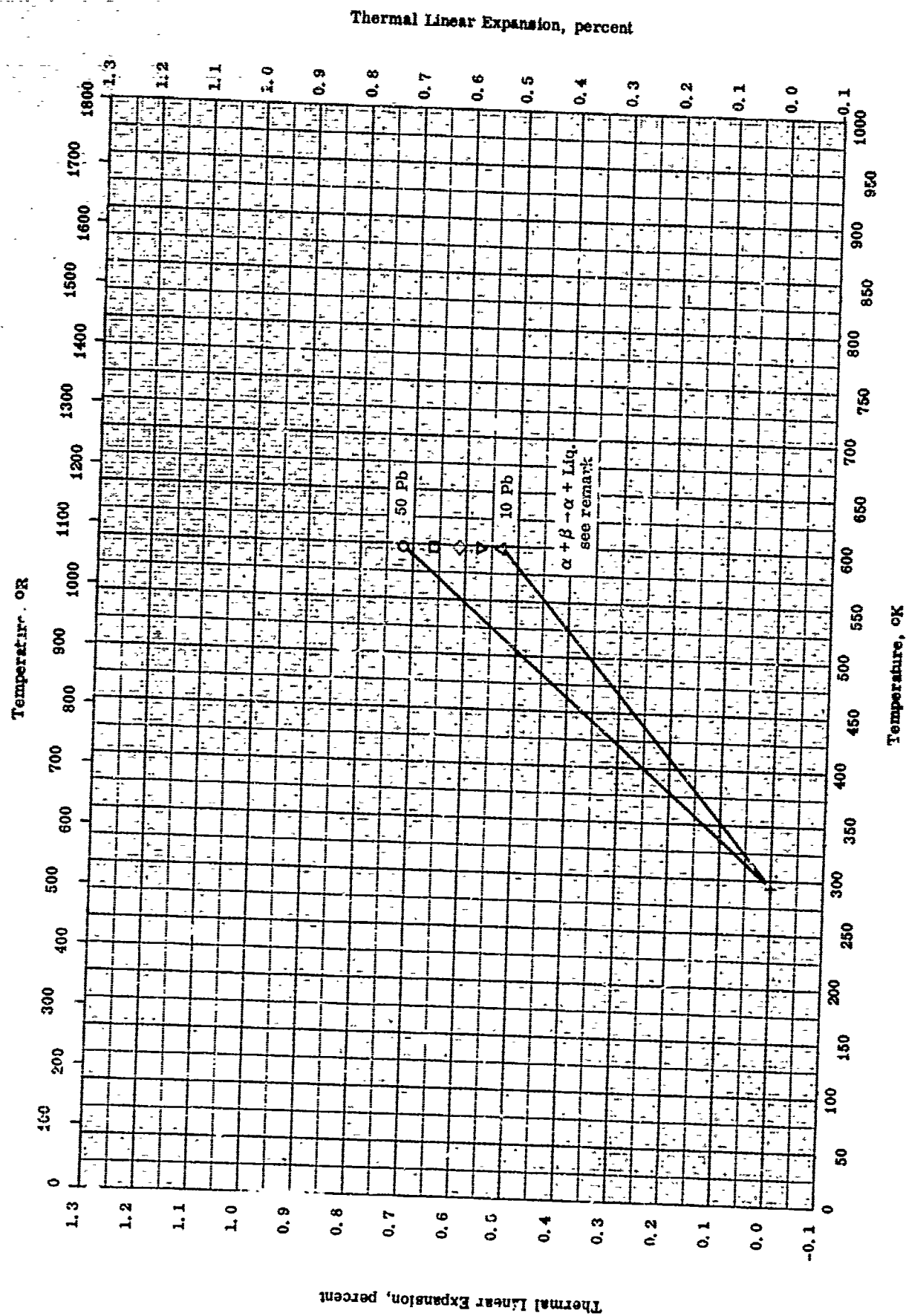
REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| ○ 10 Pb | 9.13 | 570 |
| □ 20 Pb | 9.33 | 582 |
| △ 30 Pb | 9.54 | 595 |
| ▽ 40 Pb | 9.76 | 609 |
| ◇ 50 Pb | 10.0 | 624 |

PROPERTIES OF COPPER + LEAD

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 57-40 | 298 | | 10 Pb. | Density by weight in air and in water. |
| □ | 57-40 | 298 | | 20 Pb. | Same as above. |
| △ | 57-40 | 298 | | 30 Pb. | Same as above. |
| ▽ | 57-40 | 298 | | 40 Pb. | Same as above. |
| ◇ | 57-40 | 298 | | 50 Pb. | Same as above. |



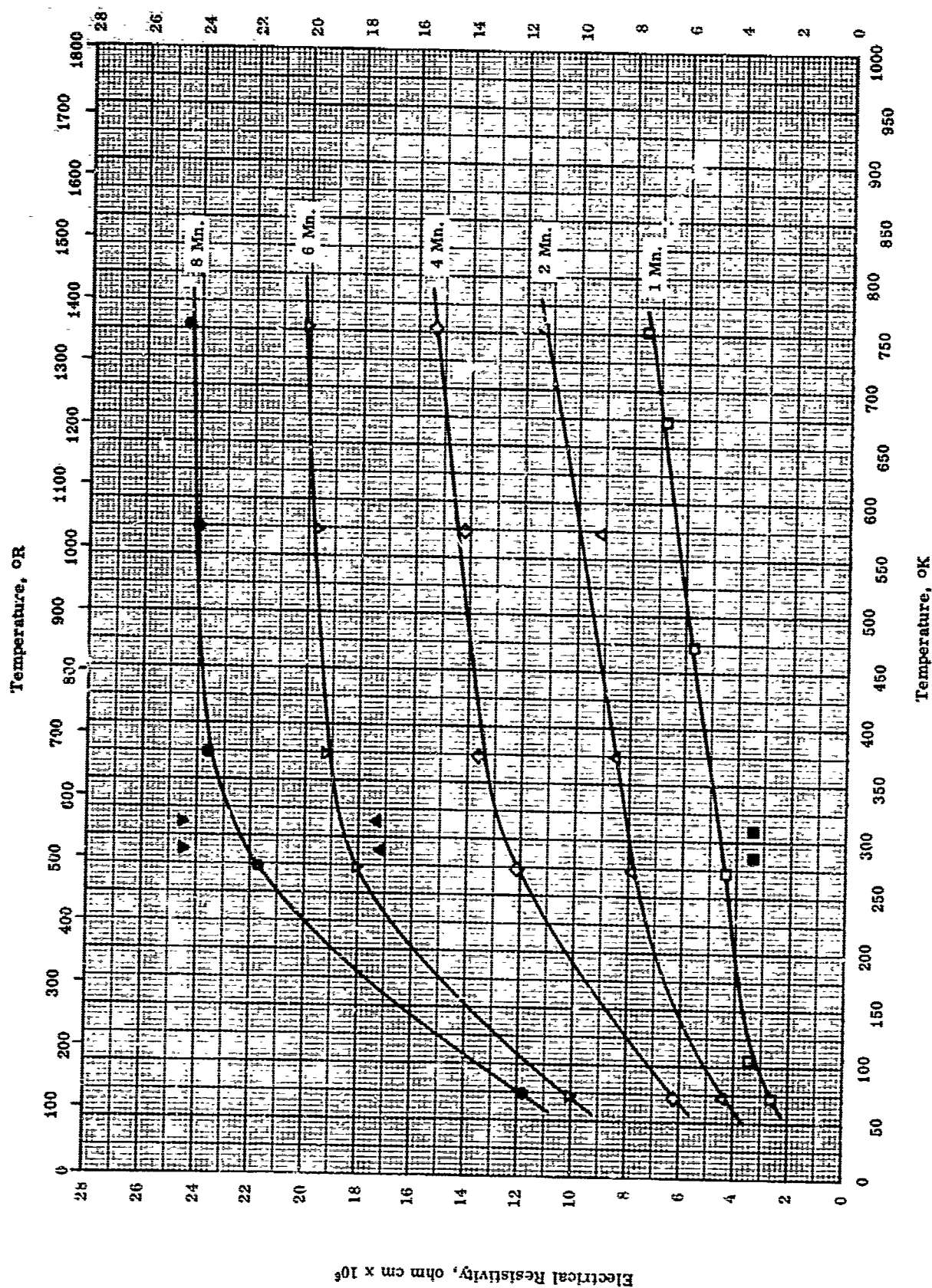
Thermal Linear Expansion -- COPPER + LEAD

THERMAL LINEAR EXPANSION -- COPPER + LEAD

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| Δ | 57-40 | 293-600 | | 90 Cu and 10 Pb. | $\alpha + \beta \rightarrow \alpha + \text{Liq.}$ at 326 C; $\Delta L/L$ at 326 C = 0. |
| ◇ | 57-40 | 293-600 | | 80 Cu and 20 Pb. | Same as above; $\Delta L/L$ at 326 C = -0.043%. |
| ▽ | 57-40 | 293-600 | | 70 Cu and 30 Pb. | Same as above; $\Delta L/L$ at 326 C = -0.015%. |
| □ | 57-40 | 293-600 | | 60 Cu and 40 Pb. | Same as above; $\Delta L/L$ at 326 C = -0.07%. |
| ○ | 57-40 | 293-600 | | 50 Cu and 50 Pb. | Same as above; $\Delta L/L$ at 326 C = -0.18%. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- COPPER + MANGANESE

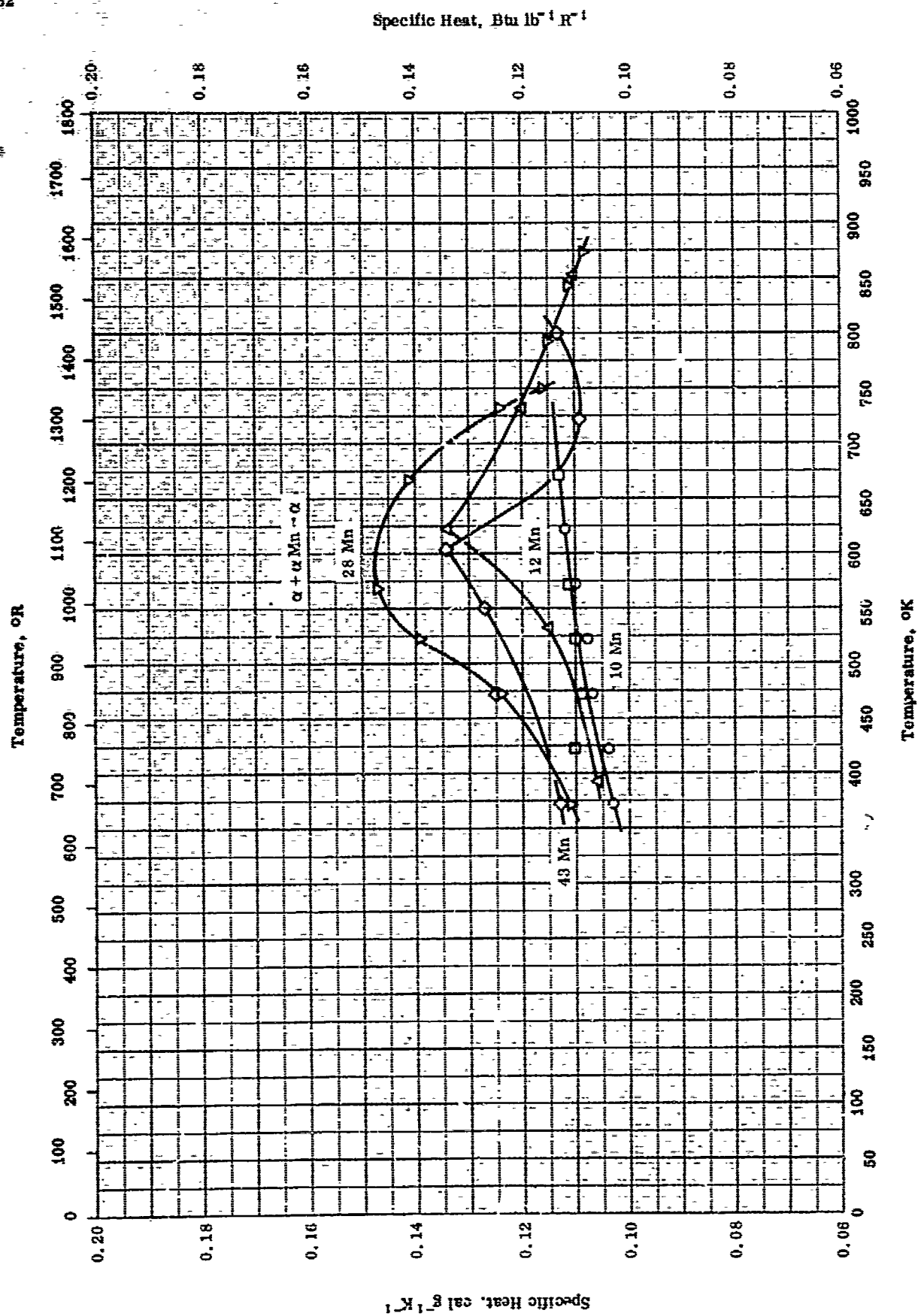
TPRC

ELECTRICAL RESISTIVITY -- COPPER + MANGANESE

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| □ | 56-26 | 73-773 | | 1 Mn; prepared from 99.99 pure raw material. | Vacuum melted 100 C above melting point, homogenized 24 hrs at 900 C, swaged, and annealed 1 hr at 500 C. |
| △ | 56-26 | 73-773 | | 2 Mn, raw materials same as above. | Same as above. |
| ◇ | 56-26 | 73-773 | | 4 Mn, raw materials same as above. | Same as above. |
| ▽ | 56-26 | 73-773 | | 6 Mn, raw materials same as above. | Same as above. |
| ● | 56-26 | 73-773 | | 8 Mn, raw materials same as above. | Same as above. |
| ■ | 56-32 | 288-313 | | 0.553 Mn, 0.004 > Si, 0.008 > Mg, and 0.001 > each of others. | Relative resistance values for many alloys in the system Cu + Mn + Ni + Fe. |
| ▲ | 56-32 | 288-313 | | 5.27 Mn, 0.004 > Si, 0.008 > Mg, and 0.001 > each of others. | |
| ▼ | 56-32 | 288-313 | | 7.44 Mn, 0.004 > Si, 0.008 > Mg, and 0.001 > each of others. | |

TPRC

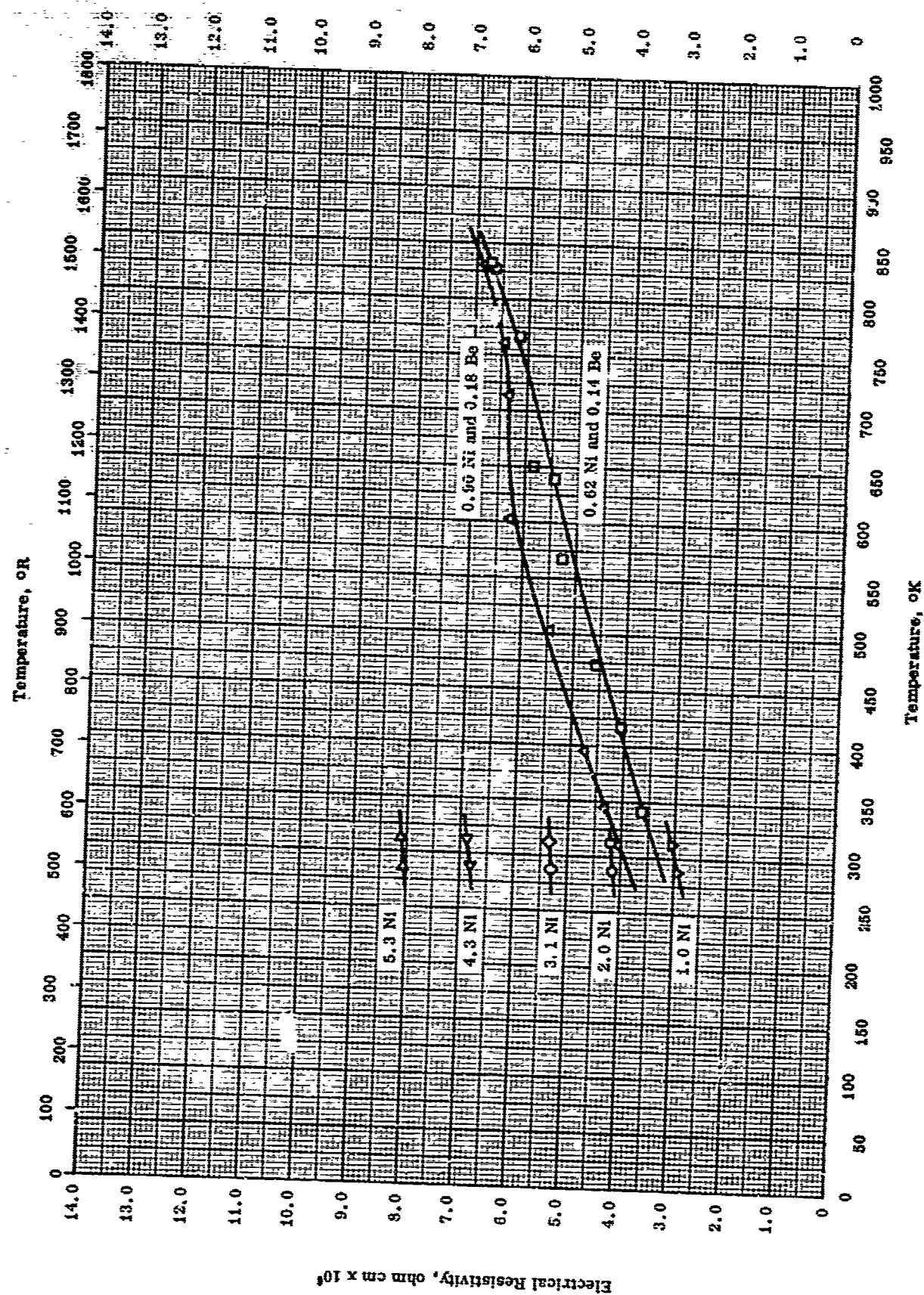


SPECIFIC HEAT -- COPPER + MANGANESE

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|----------------------|------------------|-----------------------|---|
| ○ | 55-11 | 373-873 | | 90 Cu and 10 Mn. | Quenched from 800 C; annealed 2000 hrs at 130 C. |
| □ | 55-15 | 373-873 | | 90 Cu and 10 Mn. | Cooled from 600 C at 3 C min ⁻¹ . |
| △ | 55-12 | 373-873 | | 12.3 Mn. | Melted; homogenized 7 days at 800 C in CO ₂ atmosphere; cooled 14 days at 200 C in furnace. |
| ▽ | 55-12 | 373-873 | | 28.3 Mn. | Same as above. |
| ◇ | 55-12 | 373-873 | | 43.1 Mn. | Same as above. |

TPRC

Electrical Resistivity, ohm-cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- COPPER + NICKEL

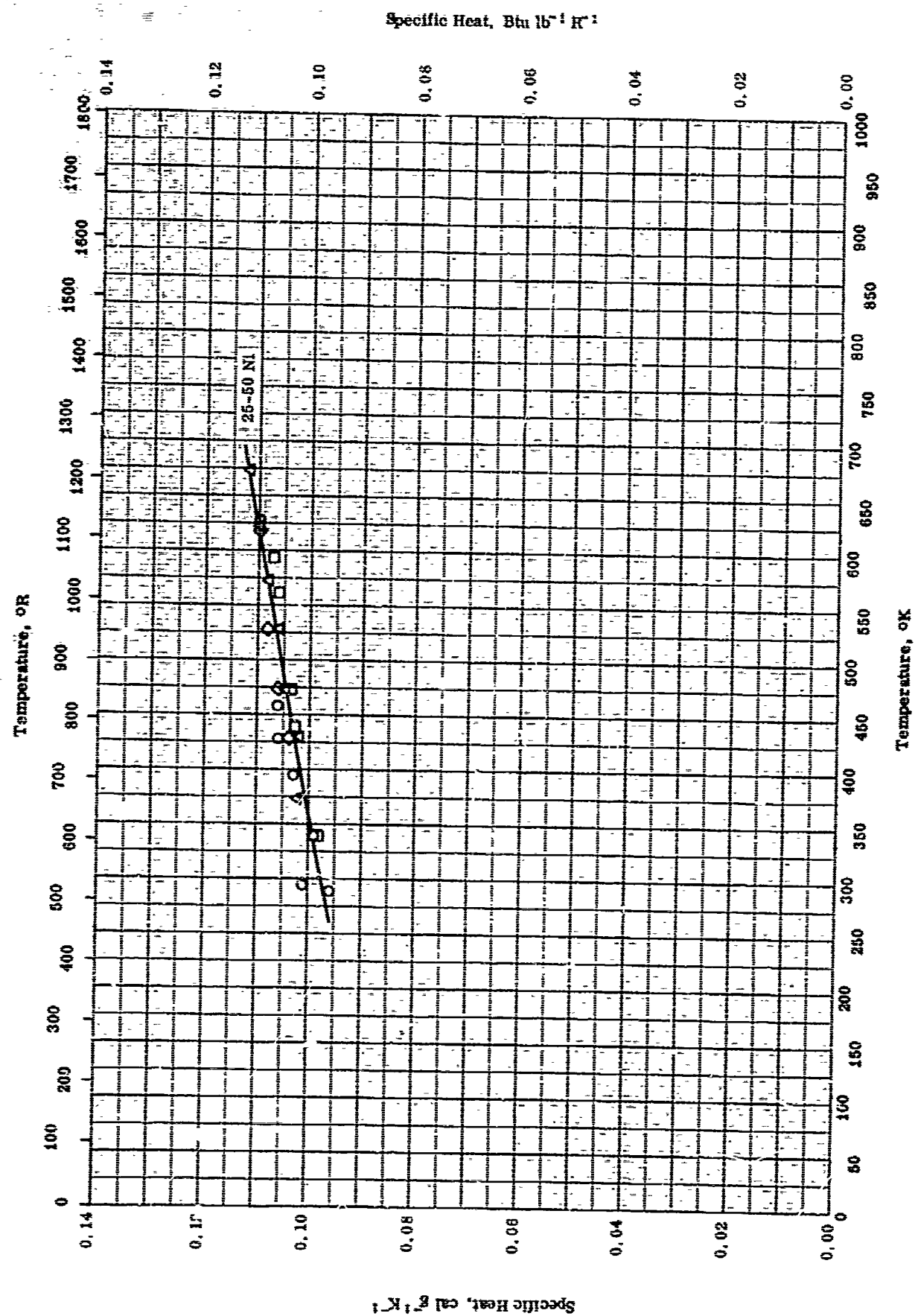
TPRC

ELECTRICAL RESISTIVITY -- COPPER + NICKEL

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|---|-------------|
| ▽ | 56-32 | 288-313 | | 1.029 Ni, 0.008 > Mg, 0.004 > Si, 0.001 > each of others. | |
| ○ | 56-32 | 288-313 | | 2.012 Ni, 0.008 > Mg, 0.004 > Si, and 0.001 > each of others. | |
| ◇ | 56-32 | 288-313 | | 3.101 Ni, 0.008 > Mg, 0.004 > Si, and 0.001 > each of others. | |
| ◁ | 56-32 | 288-313 | | 4.327 Ni, 0.008 > Mg, 0.004 > Si, and 0.001 > each of others. | |
| △ | 56-32 | 288-313 | | 5.286 Ni, 0.008 > Mg, 0.004 > Si, and 0.001 > each of others. | |
| □ | 56-6 | 343-836 | | 0.02 Ni and 0.14 %e. | Normalized. |
| △ | 56-6 | 311-831 | | 0.90 Ni and 0.18 %e. | Normalized. |

TPRC



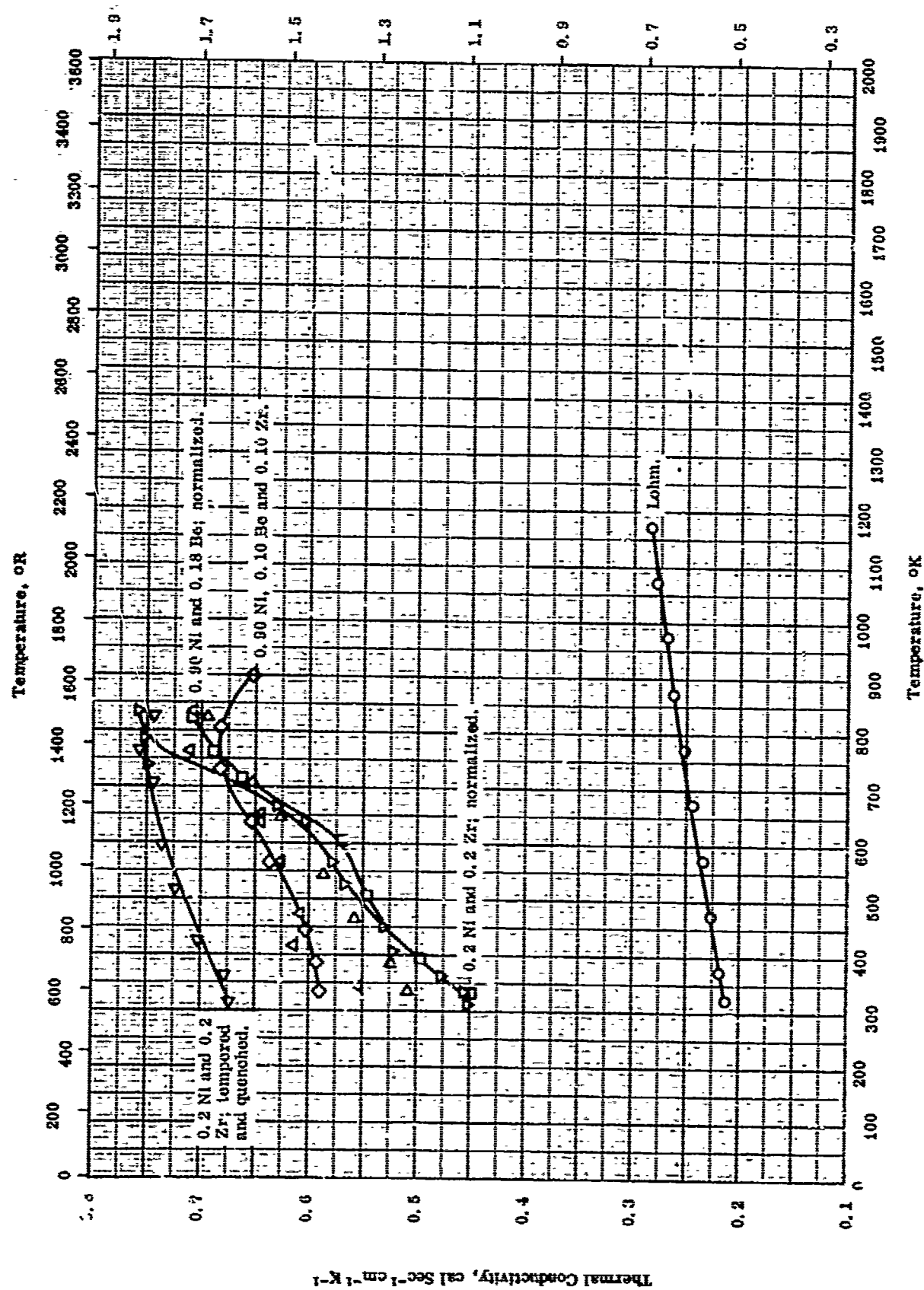
SPECIFIC HEAT -- COPPER + NICKEL

SPECIFIC HEAT -- COPPER + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 40-3 | 289-627 | 0.5 | 50 Cu and 50 Ni. | Under vacuum. |
| □ | 40-3 | 298-596 | 0.5 | 75 Cu and 25 Ni. | Same as above. |
| △ | 55-15 | 373-673 | | 75 Cu and 25 Ni. | Quenched from 800 C; annealed 2000 hrs at 130 C. |
| ◇ | 55-15 | 373-673 | | 75 Cu and 25 Ni. | Cooled from 600 C at 3 C min ⁻¹ . |

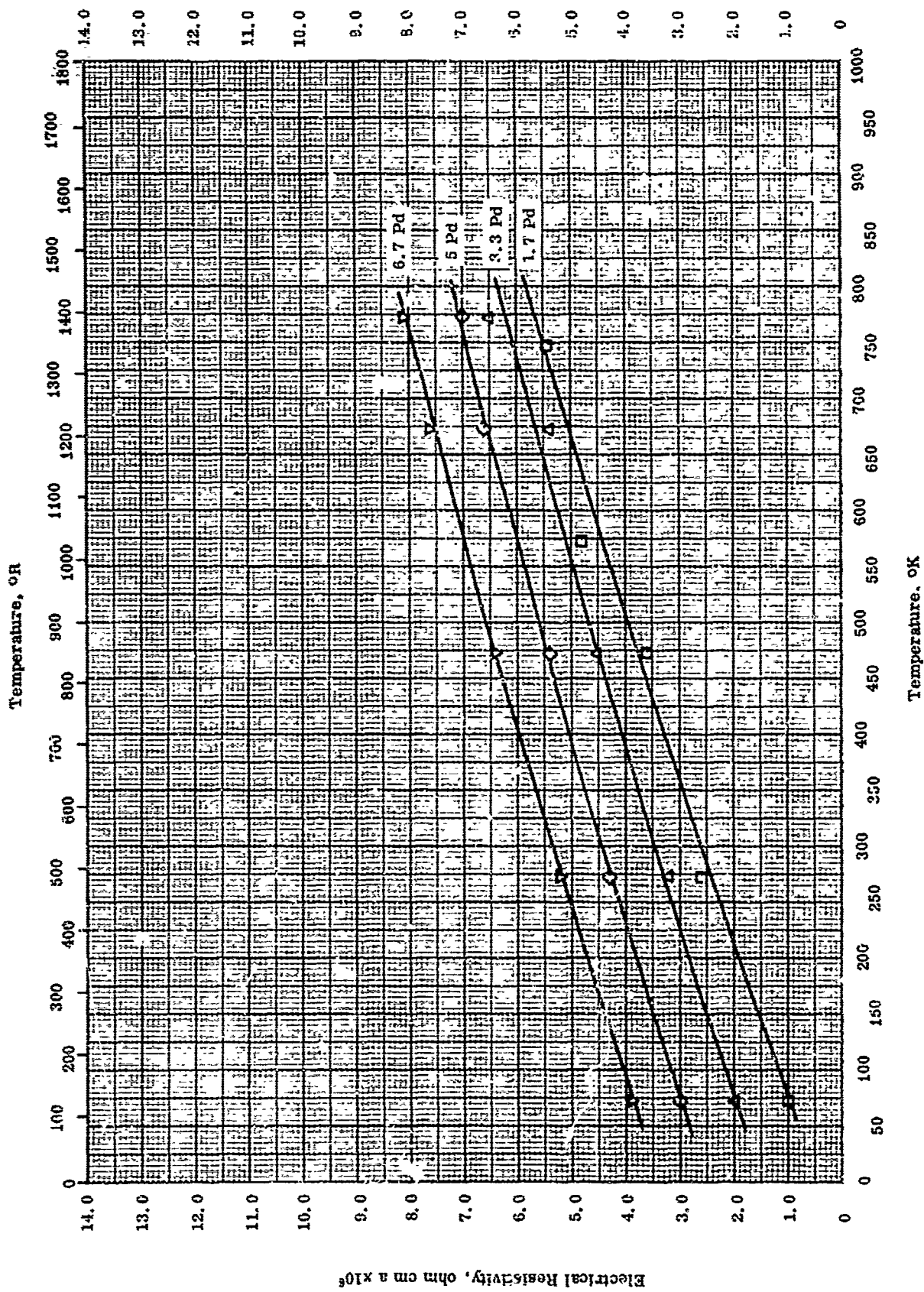
TPRC



THERMAL CONDUCTIVITY -- COPPER + NICKEL

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|------------------------|
| ○ | 63-2 | 323-1173 | | Lohm; 93.4 Cu, 6.05 Ni, 0.01 each Mn and Si. | Normalized. |
| □ | 66-6 | 311-831 | | 0.90 Ni, 0.18 Bo. | Normalized. |
| △ | 66-6 | 343-830 | | 0.02 Ni, 0.14 Bo. | Normalized. |
| ▽ | 66-6 | 311-835 | | 0.2 Ni, 0.2 Zr, 0.18 Cr, 0.1 - 0.2 Ta. | Quenched and tempered. |
| ▽ | 66-6 | 314-827 | | Same as above. | |
| △ | 67-2 | 330-826 | | 99.05 Cu, 0.70 Ni, 0.15 Co, and 0.10 Bo. | |
| ◇ | 67-3 | 333-000 | | 98.9 Cu, 0.90 Ni, 0.10 Bo, and 0.10 Zr. | |

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- COPPER + PALLADIUM

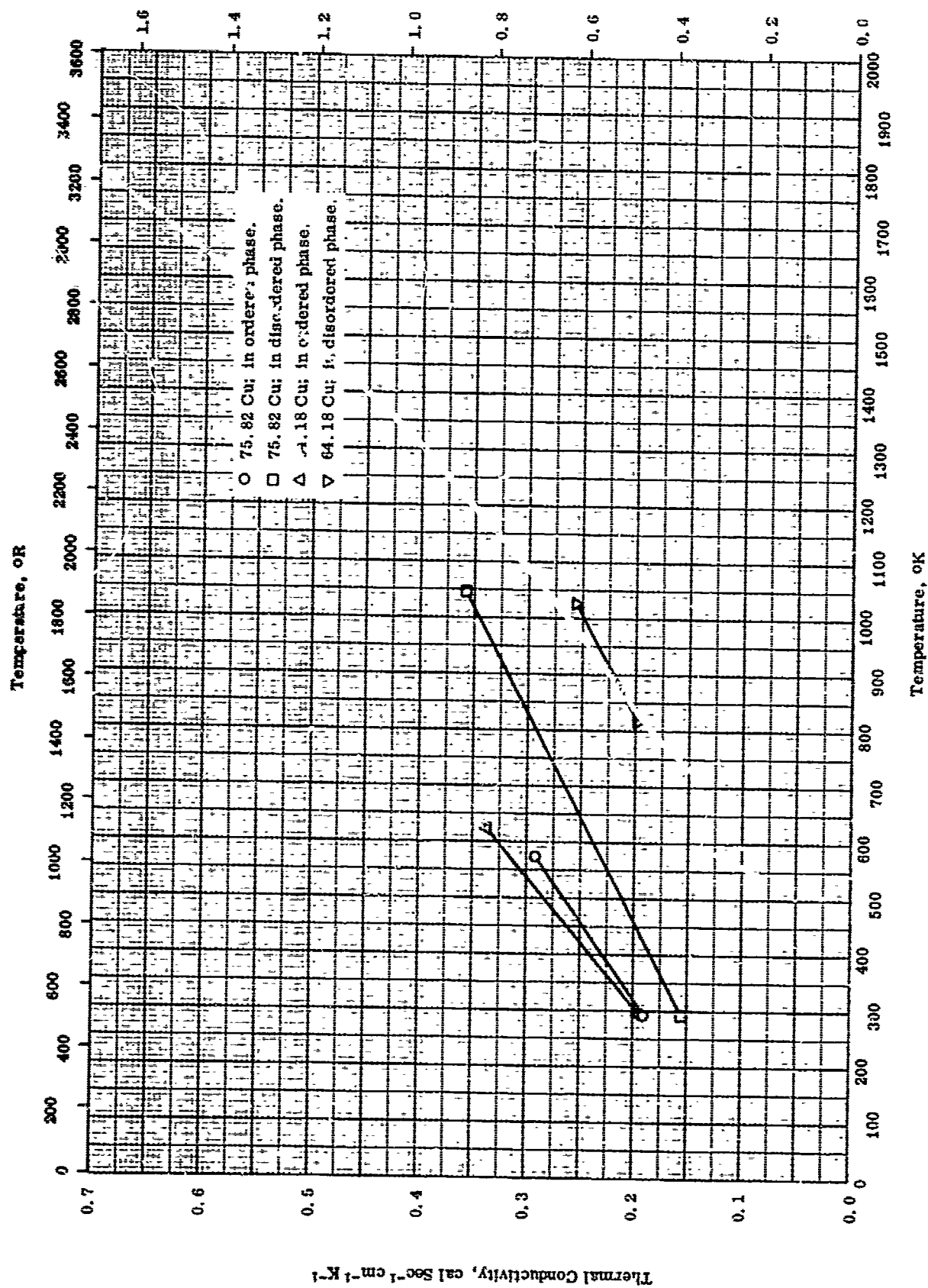
TPRC

ELECTRICAL RESISTIVITY -- COPPER + PALLADIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| □ | 56-26 | 73-773 | | 1.7 Pd; prepared from 99.99 pure raw materials | Vacuum melted 100 C above melting point, homogenized 24 hrs at 900 C, swaged, and annealed 1 hr at 500 C. |
| △ | 56-26 | 73-773 | | 3.3 Pd; raw materials same as above. | Same as above. |
| ◇ | 56-26 | 73-773 | | 5 Pd; raw materials same as above. | Same as above. |
| ▽ | 56-26 | 73-773 | | 6.7 Pd; raw materials same as above. | Same as above. |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$ 

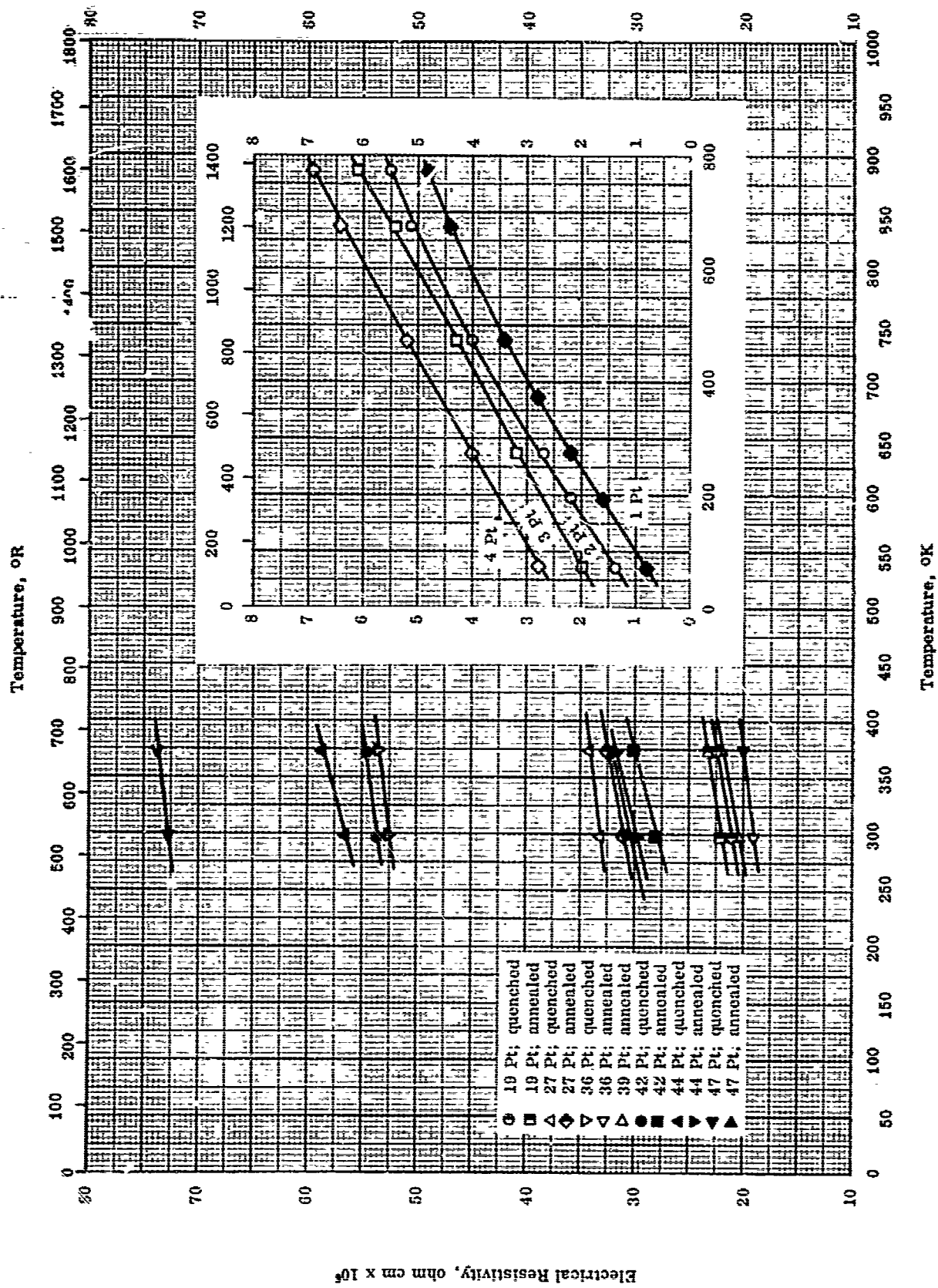
THERMAL CONDUCTIVITY -- COPPER + PALLADIUM

THERMAL CONDUCTIVITY -- COPPER + PALLADIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|--------------------|------------------|--|----------------------------------|
| O | 58-4 | 293-573 | 3 | 75-82 Cu and 24.18 Pd; ordered atomic arrangement. | Annealed at 600-700 C for 2 hrs. |
| □ | 58-4 | 293-1048 | 3 | Same as above; disordered atomic arrangement. | Same as above. |
| △ | 58-4 | 293-623 | 3 | 64.18 Cu and 35.82 Pd; ordered atomic arrangement. | Same as above. |
| ▽ | 58-4 | 818-1023 | 3 | Same as above; disordered atomic arrangement. | Same as above. |

TI-RC



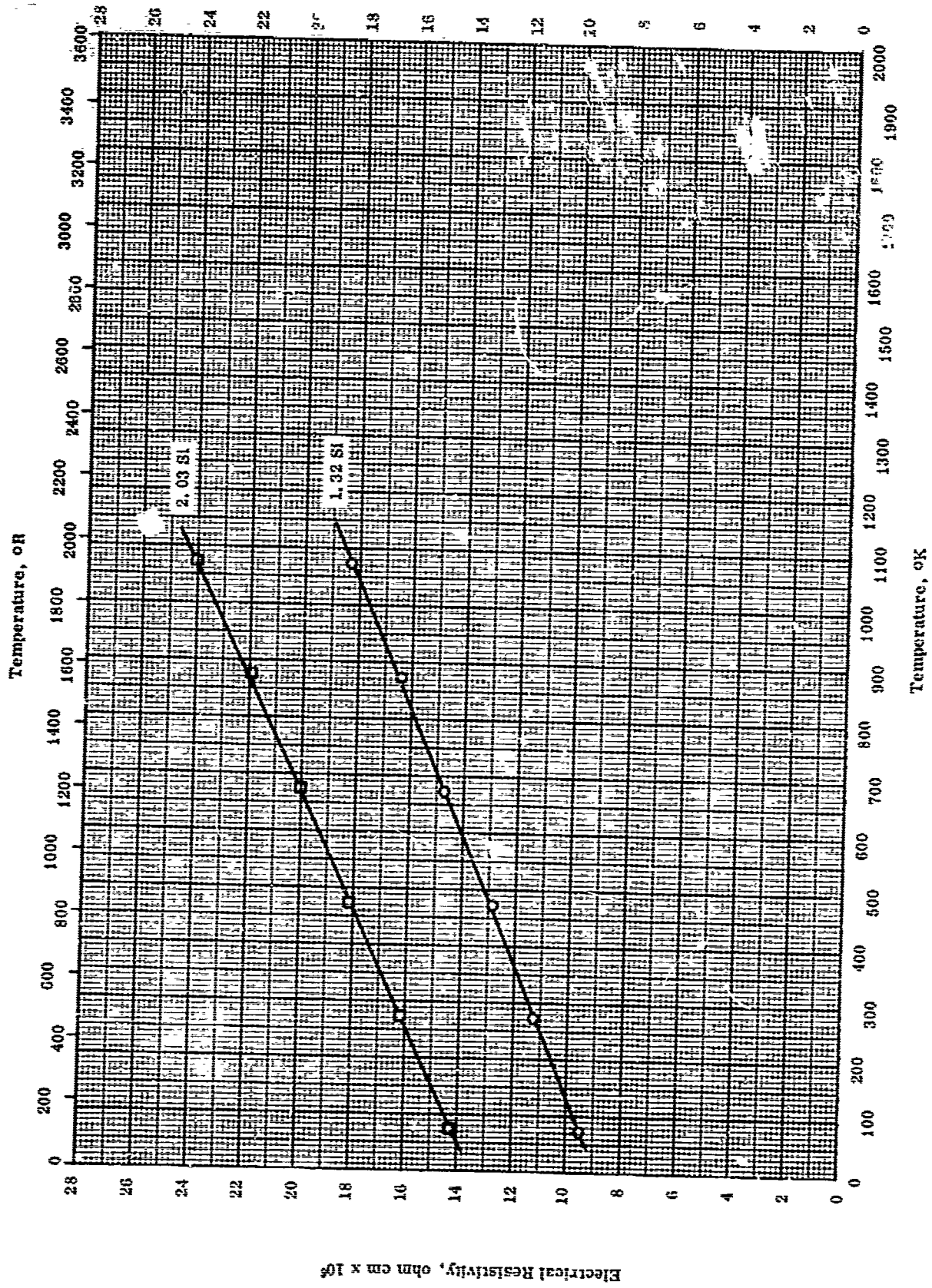
ELECTRICAL RESISTIVITY -- COPPER + PLATINUM

ELECTRICAL RESISTIVITY -- COPPER + PLATINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|---|--|
| ○ | 56-27 | 298-373 | | 19.40 Pt. | Quenched from 900 C. |
| ■ | 56-27 | 298-373 | | Same as above. | Annealed. |
| △ | 56-27 | 298-373 | | 26.74 Pt. | Quenched from 900 C. |
| ◆ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ▽ | 56-27 | 298-373 | | 35.96 Pt. | Quenched from 900 C. |
| ◁ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ▷ | 56-27 | 298-373 | | 38.9 Pt. | Annealed. |
| ● | 56-27 | 298-373 | | 41.58 Pt. | Quenched from 900 C. |
| ■ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ▲ | 56-27 | 298-373 | | 43.70 Pt. | Quenched from 900 C. |
| ▼ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ◀ | 56-27 | 298-373 | | 47.43 Pt. | Quenched from 900 C. |
| ▶ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ◆ | 56-26 | 73-773 | | 1.0 Pt; prepared from 99.99 pure raw materials. | Vacuum annealed at 100 C above melting point, homogenized 24 hrs at 900 C, swaged, and annealed 1 hr at 500 C. |
| ○ | 56-26 | 73-773 | | 2.0 Pt; same as above. | Same as above. |
| □ | 56-26 | 73-773 | | 3.0 Pt; same as above. | Same as above. |
| ◇ | 56-26 | 73-773 | | 4.0 Pt; same as above. | Same as above. |

Electrical Resistivity, ohm cm x 10³



TPRC

ELECTRICAL RESISTIVITY -- COPPER + SILICON

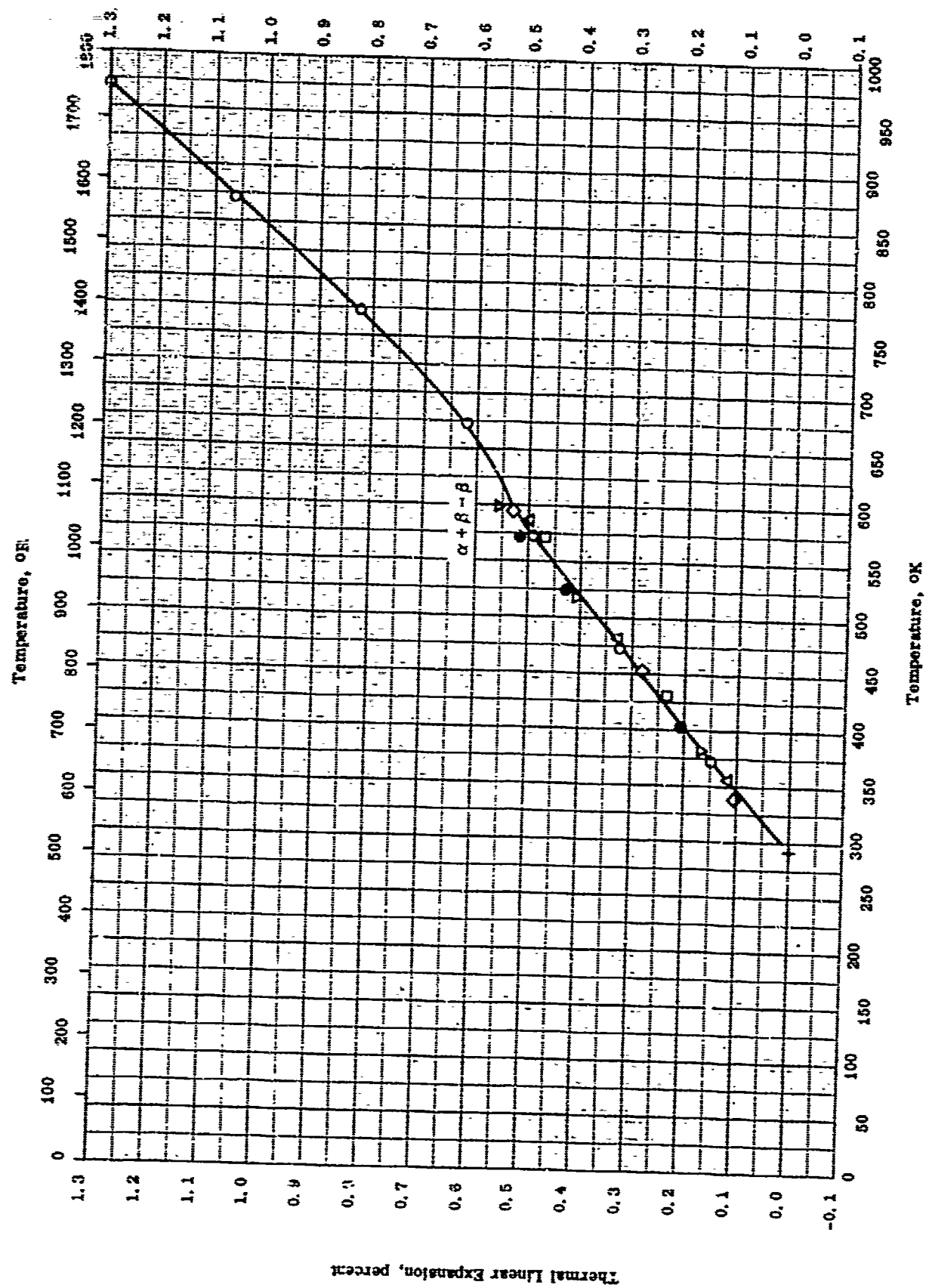
ELECTRICAL RESISTIVITY -- COPPER + SILICON

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-----------------------|-------------------|------------------|--|--|
| O | 53-10 also 55-6 | 73-1073 | | 1. 32 Si; prepared from 99.99 pure Cu and 99.97 pure Si (possibly 0.2 O ₂). | Melted in graphite crucibles under vacuum and homogenized 18 hrs just below M. P. |
| □ | 53-10 also 55-6 | 73-1073 | | 2. 03 Si; raw materials same as above. | Same as above. |

TPRC

Thermal Linear Expansion, percent



THERMAL LINEAR EXPANSION -- COPPER + SILVER

TPRC

THERMAL LINEAR EXPANSION -- COPPER + SILVER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 49-12 | 288-973 | | 93 Cu and 7 Ag. | Homogenized; heated at 1.6 C min ⁻¹ during test. |
| □ | 55-39 | 293-573 | | 89.5 Cu, 10.4 Ag, 0.066 As, and 0.030 P. | Cast. |
| △ | 55-39 | 293-573 | | 79.8 Cu, 20.1 Ag, 0.058 As, and 0.027 P. | Same as above. |
| ◇ | 55-39 | 293-573 | | 69.6 Cu, 30.0 Ag, 0.058 As, and 0.021 P. | Same as above. |
| ▽ | 55-39 | 293-573 | | 59.1 Cu, 40.9 Ag, 0.043 As, and 0.019 P. | Same as above. |
| ● | 55-39 | 293-573 | | 50.01 Cu, 49.98 Ag, 0.032 As, and 0.0160 P. | Same as above. |

PROPERTIES OF COPPER + TELLURIUM

REPORTED VALUES

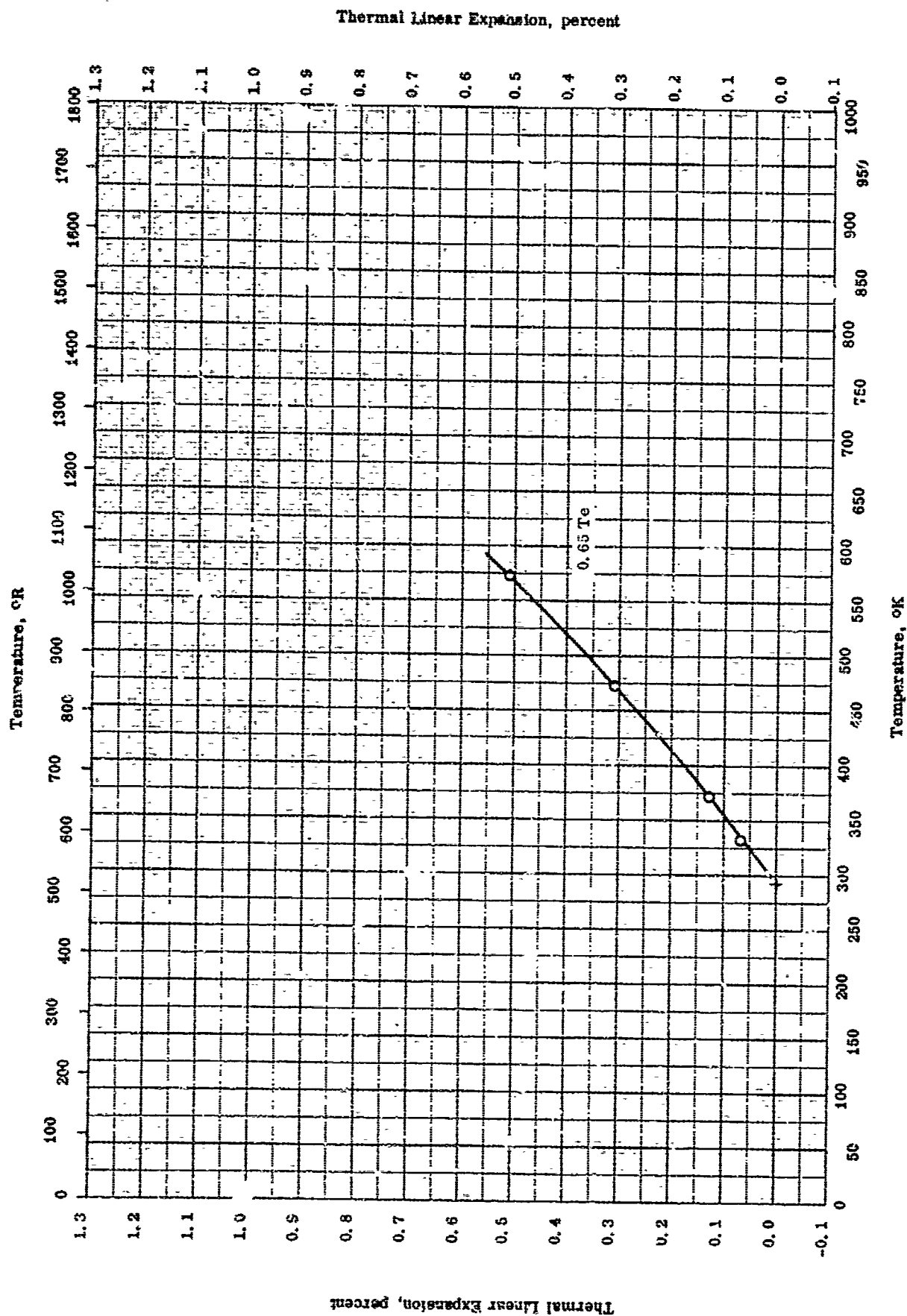
| Density: | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| ○ 0.56 Te | 8.9 | 560 |

TPRC

PROPERTIES OF COPPER + TELLURIUM

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °C | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| O | 37-34 | 208 | | 0.56 Te, 0.007 P, 0.001 Fe, Si, Ag, and Zn, and 0.001 each Al, Pb, Mg, Mn, and Sn. | |



THERMAL LINEAR EXPANSION -- CO. 2R + TELLURIUM

THERMAL LINEAR EXPANSION -- COPPER + TELLURIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|------------------------------------|
| O | 47-6 | 293-573 | | Te copper; 93.27 Cu, 0.65 Te, 0.06 Zn, 0.01 Ni, and 0.003 Fe and Pb each. | Cold drawn and annealed at 1100 F. |

TPRC

PROPERTIES OF COPPER + TIN

REPORTED VALUES

| Density | g cm^{-3} | lb ft^{-3} |
|-----------------|--------------------|---------------------|
| ○ 11 Sn; porous | 6.45 | 402 |
| □ Same as above | 6.30 | 393 |
| △ Same as above | 5.85 | 365 |
| ◇ Same as above | 5.55 | 346 |
| ▽ Same as above | 5.75 | 359 |
| ● Same as above | 5.50 | 343 |

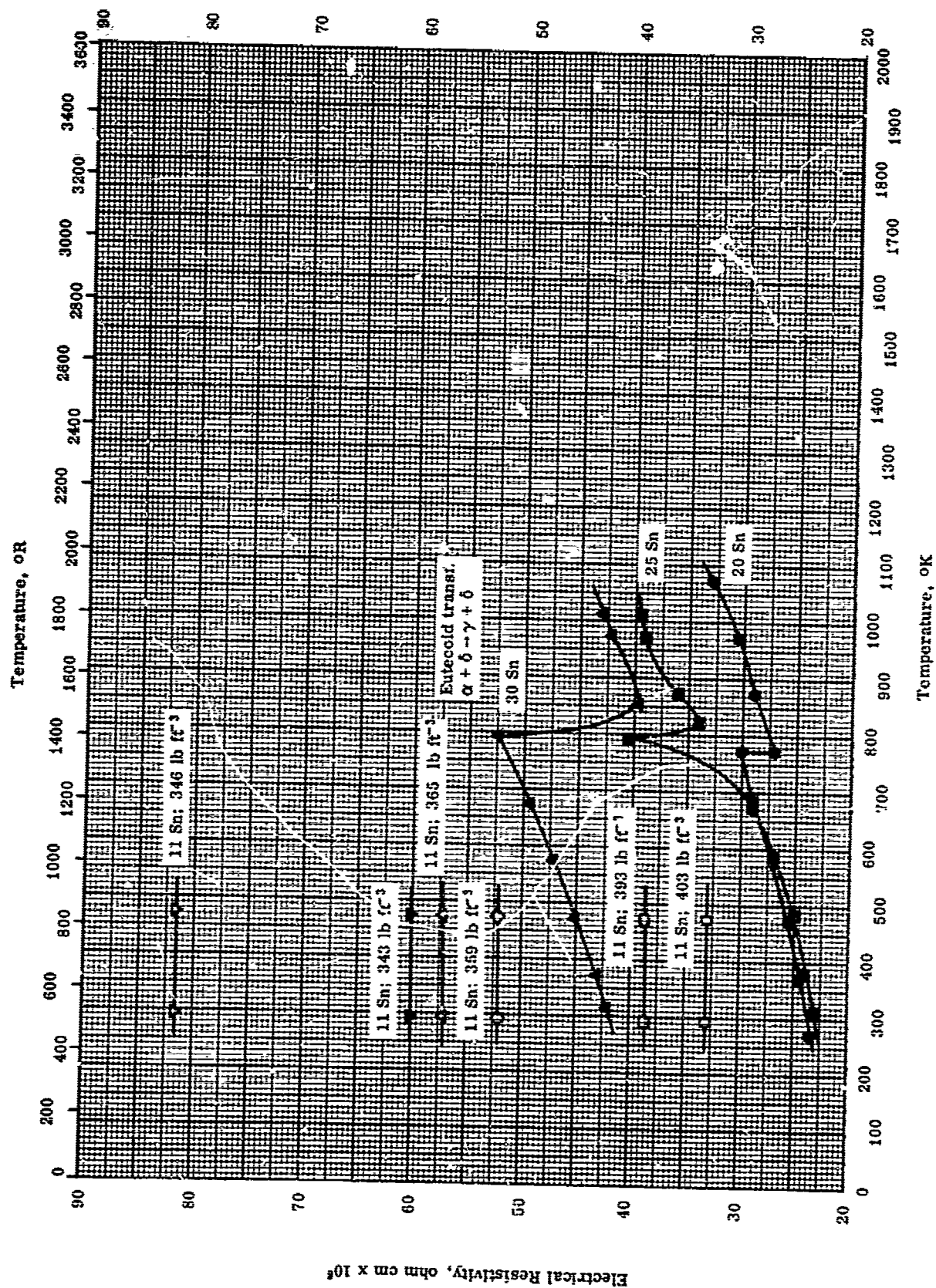
TPRC

PROPERTIES OF COPPER + TIN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|--------------------------------|
| ○ | 52-3 | 298 | | Bronze; nominal composition: 89 Cu and 11 Sn; prepared from powder with density 540 lb ft ⁻³ and dia 0.00133 cm. | Prepared by powder metallurgy. |
| □ | 52-3 | 298 | | Same as above except powder dia 0.00493 cm. | Same as above. |
| △ | 52-3 | 298 | | Same as above. | Same as above. |
| ◇ | 52-3 | 298 | | Same as above except powder dia 0.01275 cm. | Same as above. |
| ▽ | 52-3 | 298 | | Same as above except powder dia 0.02113 cm. | Same as above. |
| ● | 52-3 | 298 | | Same as above except powder dia 0.04000 cm. | Same as above. |

TPRC

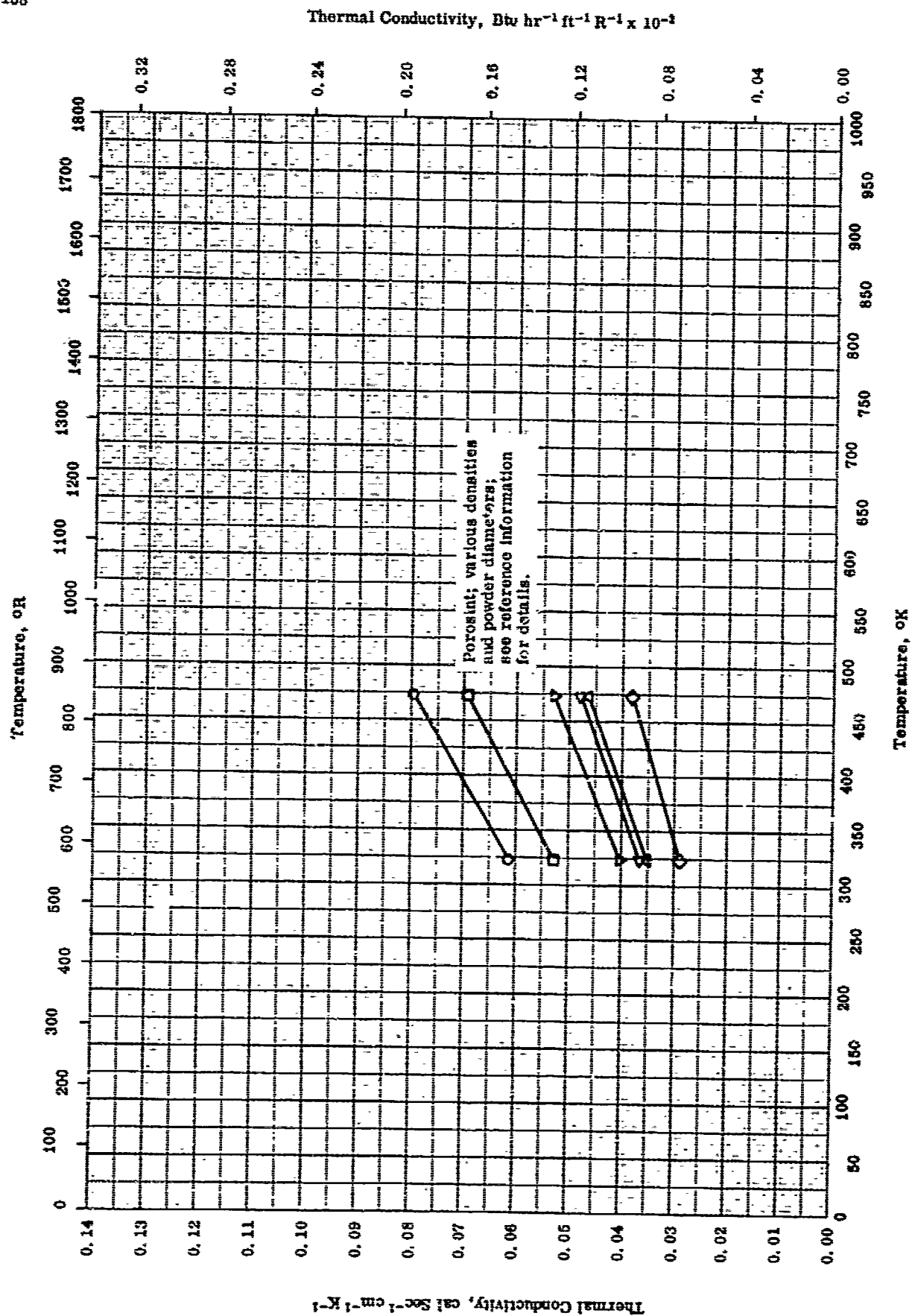
Electrical Resistivity, ohm cm x 10⁸

ELECTRICAL RESISTIVITY -- COPPER + TIN

ELECTRICAL RESISTIVITY -- COPPER + TIN

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ○ | 52-3 | 293-473 | | Bronze; from Porosint Sintered Product LTD.; nominal: 89 Cu and 11 Sn; density 403 lb ft ⁻³ ; porous. | Made from spherical shaped powder produced by atomization process; powder density 543 lb ft ⁻³ . |
| □ | 52-3 | 293-473 | | Same as above; density 393 lb ft ⁻³ . | Same as above. |
| △ | 52-3 | 293-473 | | Same as above; density 365 lb ft ⁻³ . | Same as above. |
| ◇ | 52-3 | 293-473 | | Same as above; density 359 lb ft ⁻³ . | Same as above. |
| ▽ | 52-3 | 293-473 | | Same as above; density 346 lb ft ⁻³ . | Same as above. |
| ▼ | 52-3 | 293-473 | | Same as above; density 343 lb ft ⁻³ . | Same as above. |
| ● | 57-25 | 273-1053 | | Nominal: 80 Cu and 20 Sn. | |
| ■ | 57-25 | 273-1053 | | Nominal: 75 Cu and 25 Sn. | |
| ▲ | 57-25 | 273-1053 | | Nominal: 70 Cu and 30 Sn. | |



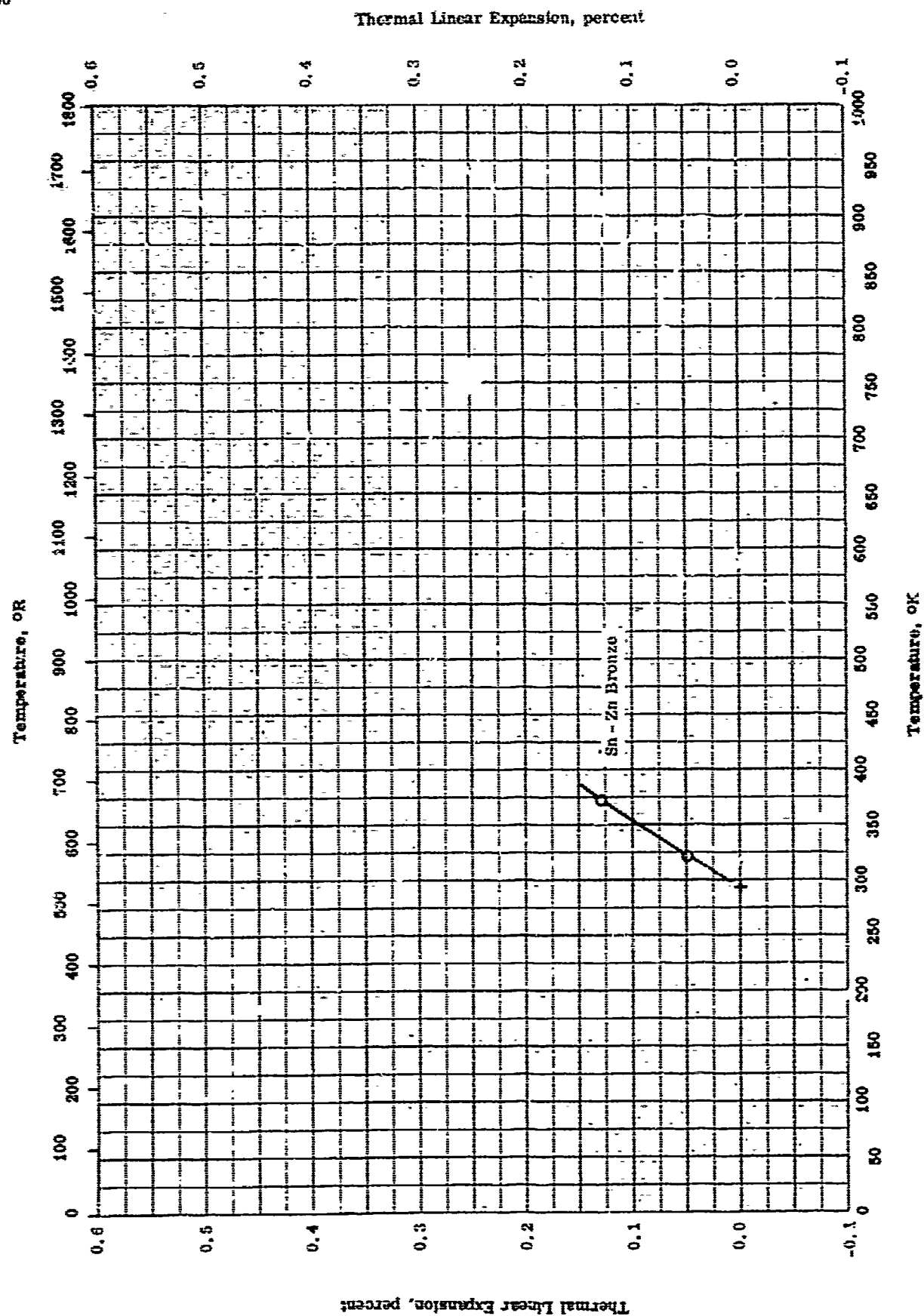
THERMAL CONDUCTIVITY -- COPPER + TIN

THERMAL CONDUCTIVITY -- COPPER + TIN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|-----------|
| ○ | 52-3 | 323-473 | | Porosint (Sintered Products Ltd.); 89 Cu and 11 Sn; density 402.5 lb ft ⁻³ ; powder dia 0.00133 cm. | Sintered. |
| □ | 52-3 | 323-473 | | Same as above; density 393.1 lb ft ⁻³ ; powder dia 0.00493 cm. | Sintered. |
| △ | 52-3 | 323-473 | | Same as above; density 365.0 lb ft ⁻³ ; powder dia 0.00493 cm. | Sintered. |
| ◇ | 52-3 | 323-473 | | Same as above; density 346.3 lb ft ⁻³ ; powder dia 0.01276 cm. | Sintered. |
| ▽ | 52-3 | 323-473 | | Same as above; density 358.8 lb ft ⁻³ ; powder dia 0.02113 cm. | Sintered. |
| ▽ | 52-3 | 323-473 | | Same as above; density 343.2 lb ft ⁻³ ; powder dia 0.04000 cm. | Sintered. |

TPRC



THERMAL LINEAR EXPANSION -- COPPER + TIN

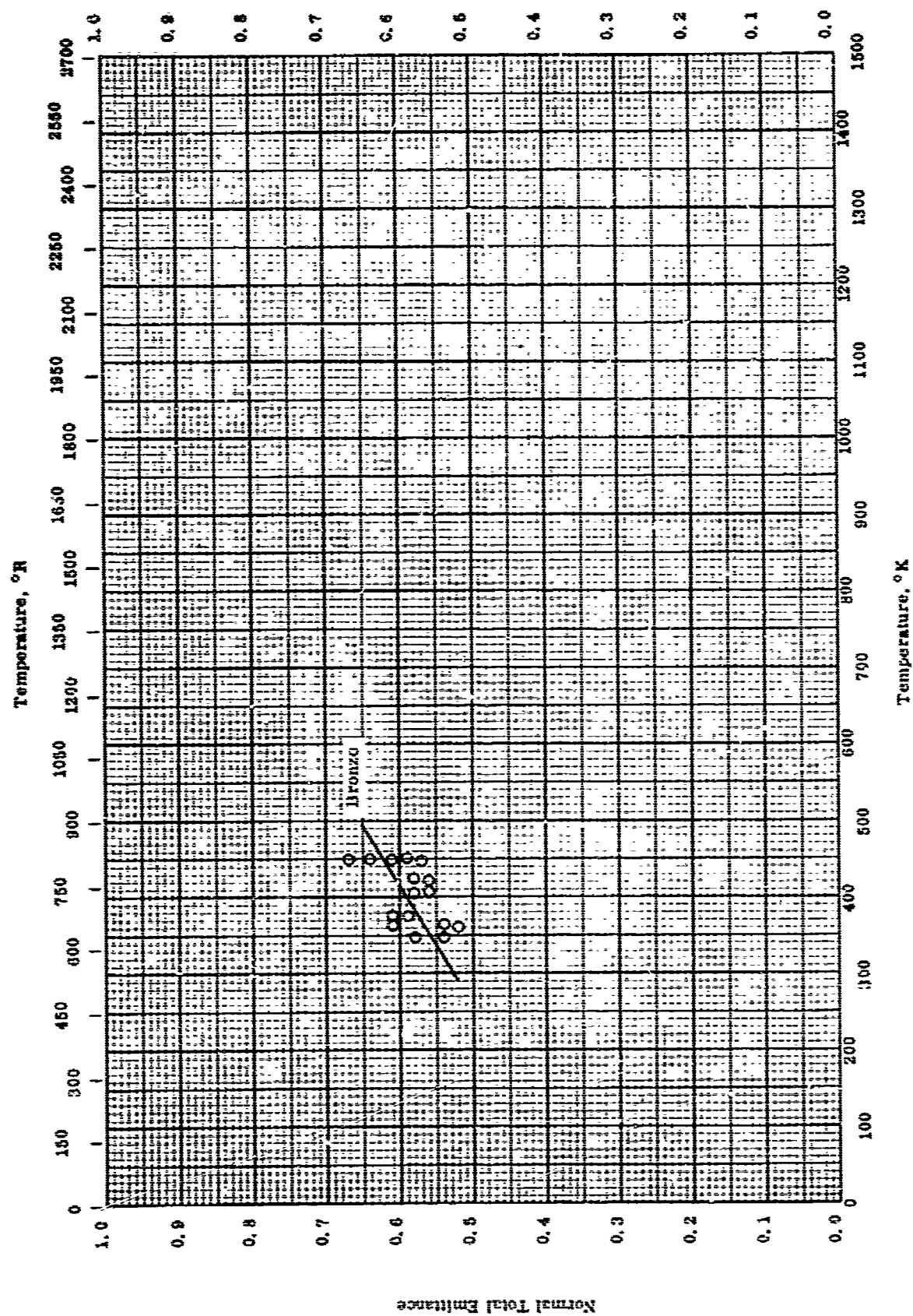
THERMAL LINEAR EXPANSION - COPPER + TIN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|--------------------------|
| O | 43-8 | 273-373 | | Sn - 2% Bronze; 98.6 Cu, 1.3 Sn, and 0.02 Fe. | Hot rolled and annealed. |

TPRC

Normal Total Emittance



NORMAL TOTAL EMITTANCE — COPPER + TIN

TPRC

NORMAL TOTAL EMITTANCE -- COPPER + TIN

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|------------------|
| 0 | 02-21 | 347-463 | | Purcosu bronzo. | Measured in air. |

PROPERTIES OF COPPER + TITANIUM

REPORTED VALUES

| Density | g cm^{-3} | lb ft^{-3} |
|---------------|--------------------|---------------------|
| ○ 40 Ti | 8.50 | 518.0 |
| Melting Point | K | R |
| □ 24 Ti | 1123 | 2021 |

TPRC

PROPERTIES OF COPPER + TITANIUM

REFERENCE INFORMATION

| Sym Bol. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|-------|-------------------|------------------|---|---|
| O | 57-44 | 298 | | 40 Ti ; from electrolytic Cu and sponge high purity Ti. | Vacuum melted and cast; turned, pressed, annealed at 650 C, and furnace cooled at 36 C hr ⁻¹ . |
| □ | 63-17 | ±123 | | 76 Cu and 24 Ti. | |

TPRC

PROPERTIES OF COPPER + URANIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------------|--------------------|---------------------|
| ○ 42.8 U | 10.6 | 662 |
| □ 42.8 U | $10.60 \pm 0.02^*$ | $661.7 \pm 1.2^*$ |
| Melting Point: | K | R |
| △ 42.8 U | 1325 | 2395 |

* Most probable value for alloys of this composition

TPRC

PROPERTIES OF COPPER + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 49-11 | 298 | | UCu ₅ ; 57.2 Cu and 42.8 U; prepared from 99.9 ⁺ U and electrolytic Cu. | Inductively melted in ZrO ₂ or BeO crucible in vacuum. |
| □ | 49-11 | 298 | | Same as above. | Same as above; density computed from x-ray data. |
| △ | 49-11 | 1325 | | Same as above. | M. P. from breaking in time-temperature curve. |

TPRC

PROPERTIES OF COPPER + ZINC

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-----------------------|--------------------|---------------------|
| O 35.7 Zn and 3.27 Pb | 8.46 | 528 |

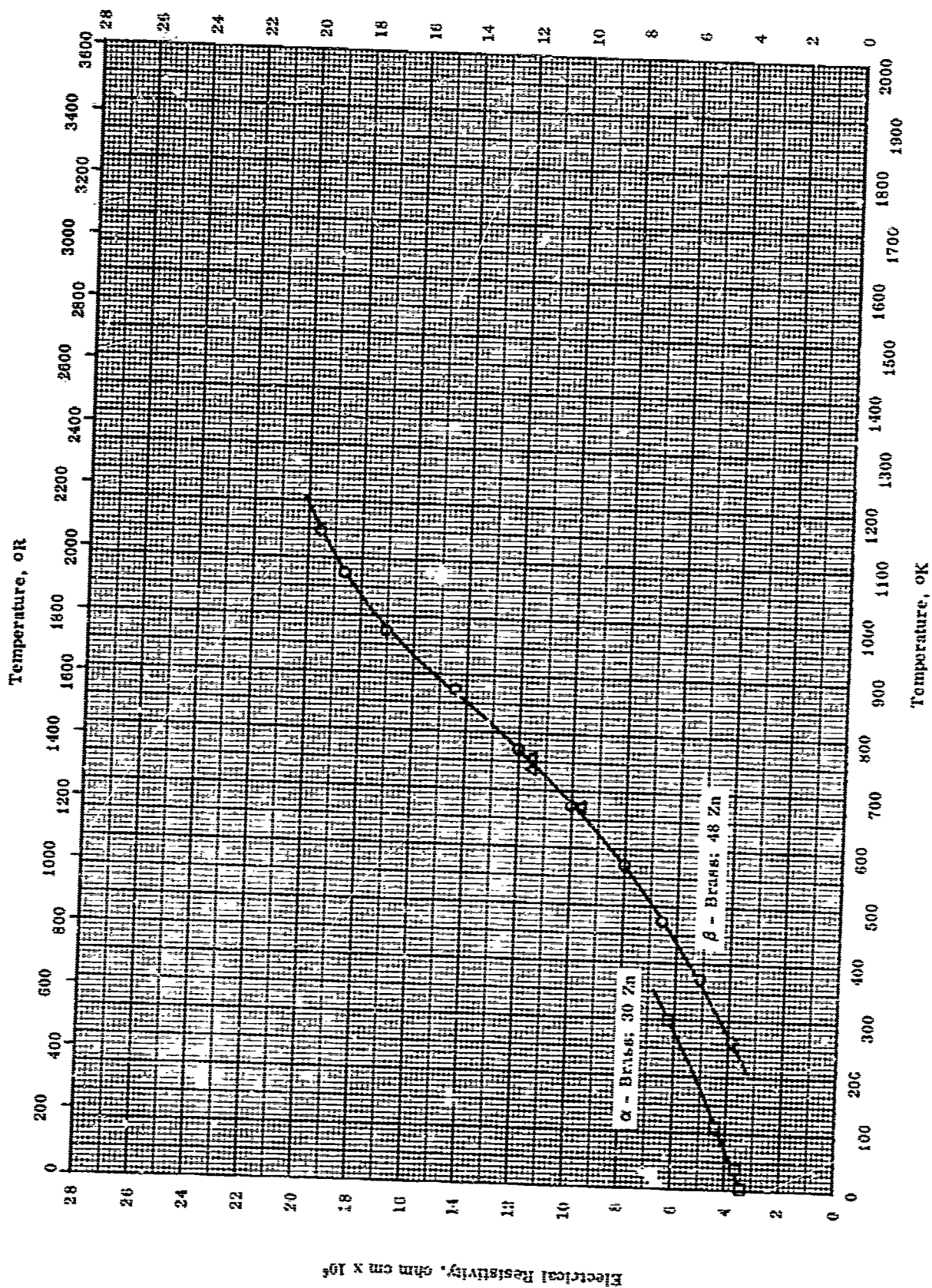
TPRC

PROPERTIES OF COPPER + ZINC

REFERENCE INFORMATION

| Syn Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| O | 57-34 | 298 | | Free cutting leaded brass; 35.7 Zn, 3.27 Pb, 1.0 Sn, and 0.01 each Bi, Cd, Fe, Ni, and Ag. | |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- COPPER + ZINC

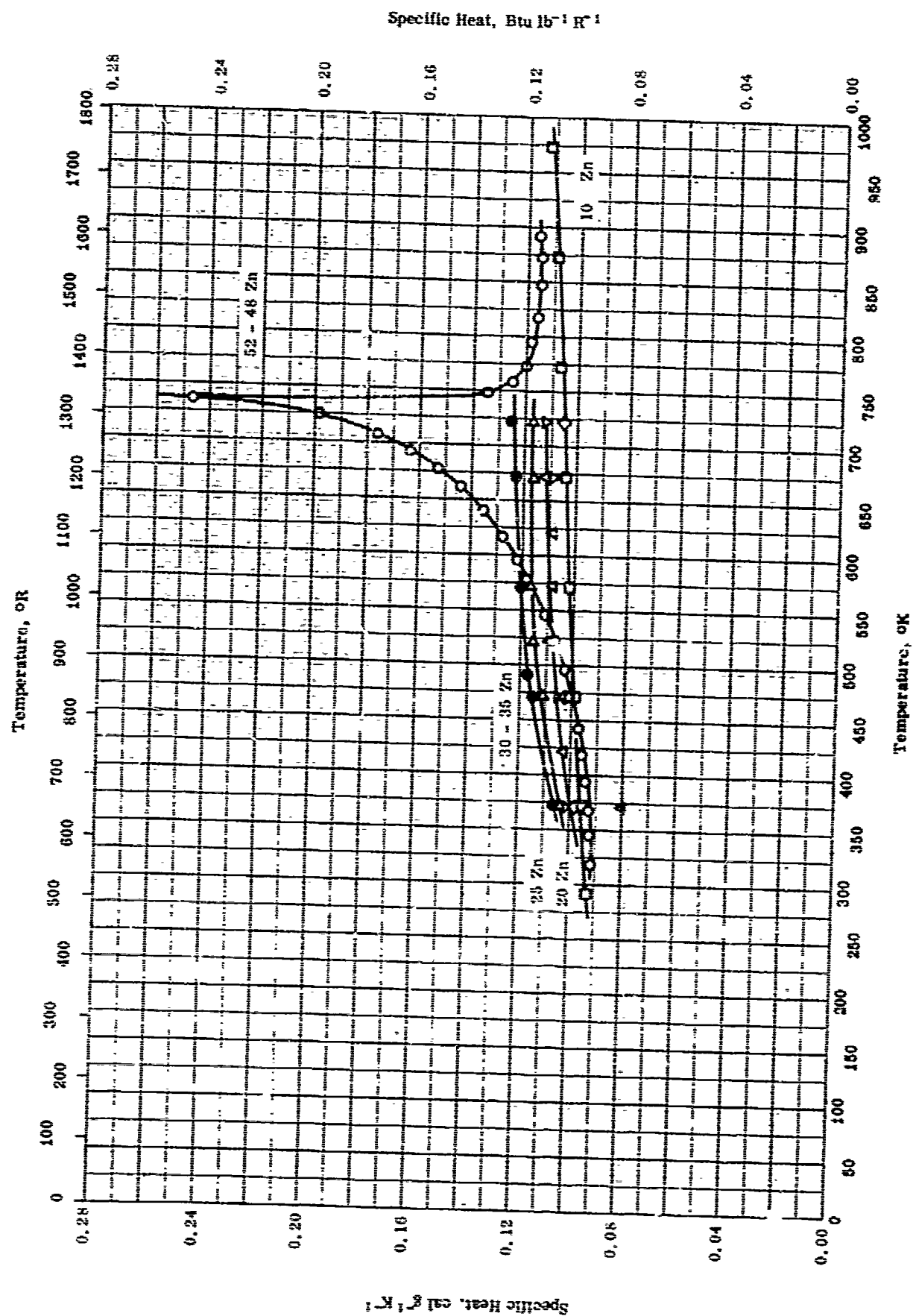
T2RC

ELECTRICAL RESISTIVITY -- COPPER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---------------------------------|---|
| ○ | 67-26 | 273-1133 | | 48 Zn. | Drawn wire; annealed 7 hrs at 592 K. Sample hold 24 hrs at each temperature before each measurement. |
| □ | 48-1 | 4-200 | | α Brass: 70 Cu and 30 Zn. | |
| △ | 52-10 | 671-753 | | β Brass: 62.21 Cu and 47.79 Zn. | |

TPRC

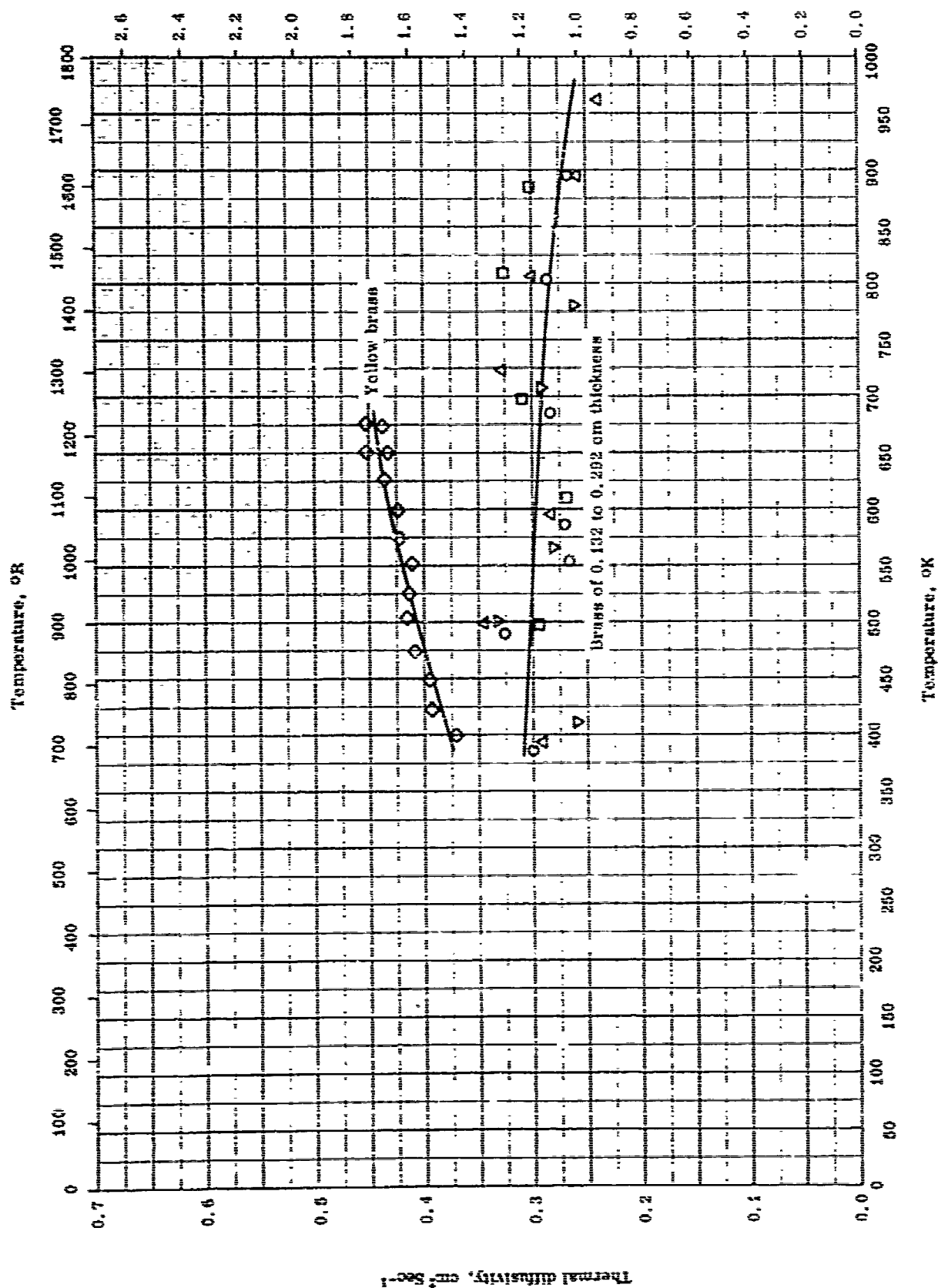


SPECIFIC HEAT --- COPPER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 30-1 | 322-893 | | Brass, β-phase; 61.8 Cu, 48.17 Zn, 0.03 Pb, and trace Fe. | Under argon atmosphere at reduced pressure. |
| □ | 40-4 | 203-973 | 2 | Brass; 10-30 Zn. | Tempered several hrs at 500 C; tested in N ₂ atmosphere. |
| △ | 55-16 | 373-673 | 4.0 | 70 Cu and 30 Zn. | Two samples: quenched from 800 C and annealed 2000 hrs at 130 C for sample 1 and cooled from 600 C at 3 C min ⁻¹ for sample 2. |
| ◇ | 52-6 | 373-723 | 2.0 | 4.56, 12.25, and 16.00 Zn. | Annealed 1 hr at 700 C; slowly cooled; average of 3 samples containing 4.56, 12.25, and 16.00 Zn. |
| ▽ | 52-6 | 373-723 | | 20.75 Zn. | Annealed 1 hr at 700 C; slowly cooled. |
| ⋈ | 52-6 | 373-723 | 5.0 | 25.75 Zn. | Treatment 1 and 2: (1) Annealed 1 hr at 700 C; slowly cooled; (2) heated 700 C, held 30 min; furnace cooled to 500 C; held 10 min, and water quenched. |
| ● | 52-6 | 373-723 | 5.0 | 30.35 and 36.87 Zn. | Samples with 30.35 Zn given treatment as above and sample with 36.87 Zn given treatment (1) only. |

TPRC

Thermal diffusivity, $\text{ft}^2 \text{hr}^{-1}$ 

TPRC

THERMAL DIFFUSIVITY -- COPPER + ZINC

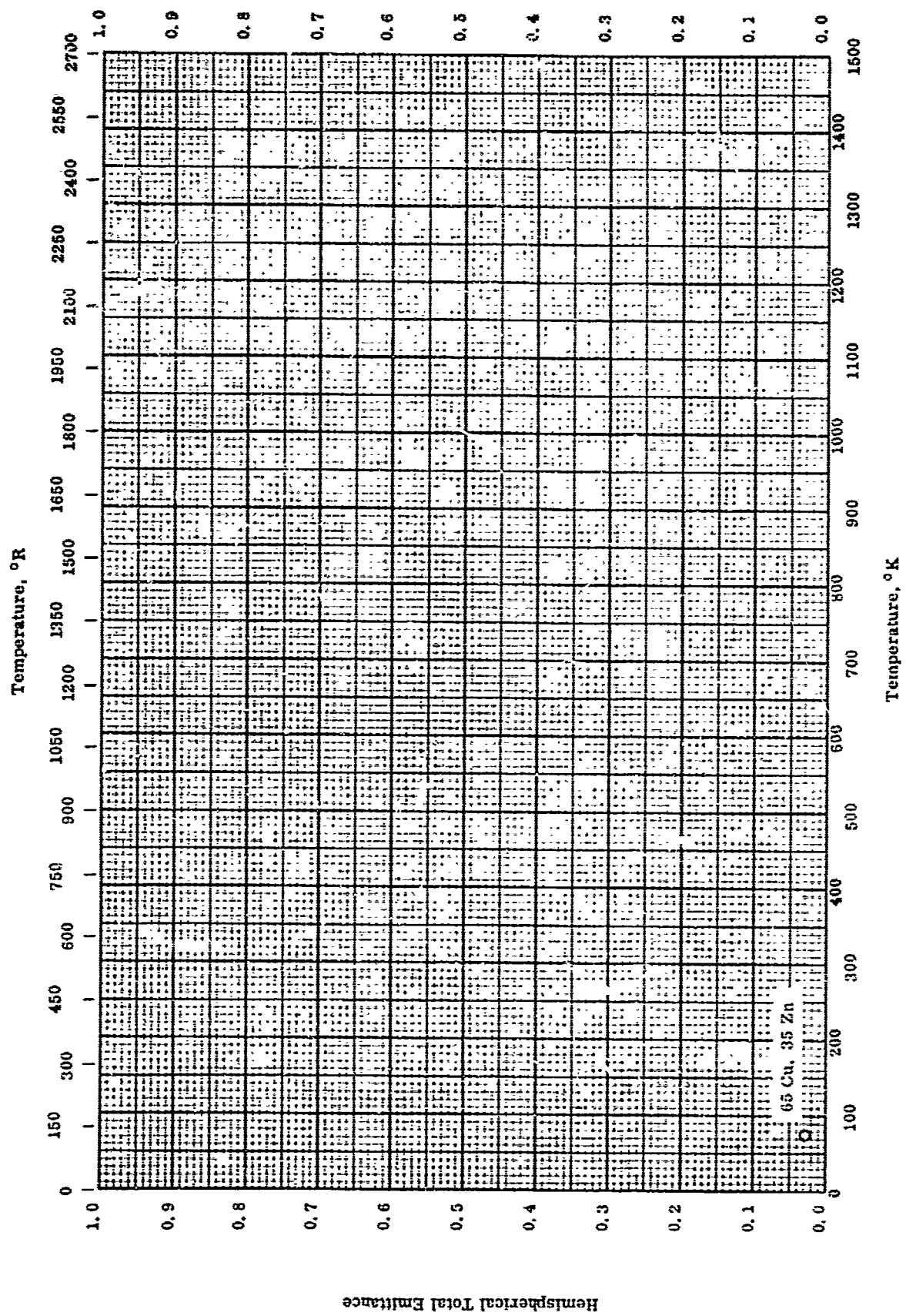
THERMAL DIFFUSIVITY --- COPPER + ZINC

REFERENCE INFORMATION

| Sym | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----|------|----------------|---------------|--|---------|
| ○ | 00-1 | 385-895 | | Brass; dia of 0.65 cm dia and 0.132 cm thick. | |
| □ | 00-1 | 407-885 | | Same as above except 0.130 cm thick. | |
| △ | 00-1 | 303-962 | | Same as above except 0.205 cm thick. | |
| ▽ | 00-1 | 410-780 | | Same as above except 0.292 cm thick. | |
| ○ | 01-1 | 398-073 | 40 | Yellow brass; 63 Cu and 35 Zn sample in tube form with 122 cm in length, 1.91 cm in dia, and 0.313 cm in wall thickness. | |

TPRC

Hemispherical Total Emittance



TPRC

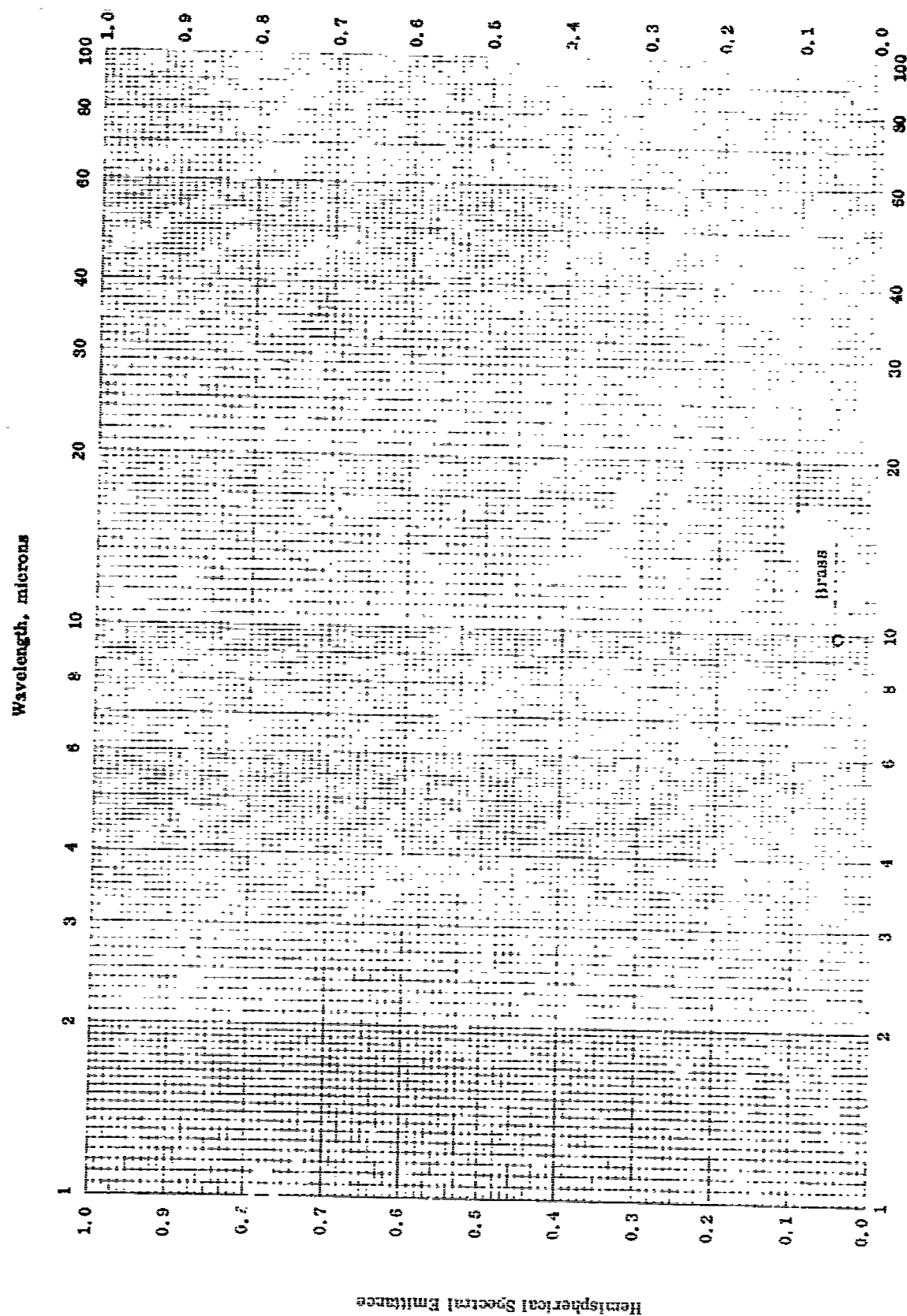
HEMISPHERICAL TOTAL EMITTANCE -- COPPER + ZINC

HEMISPHERICAL TOTAL EMITTANCE -- COPPER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 60-17 | 76 | 5 | 65 Cu, 35 Zn. | Emittance for 300 K black body radiation. |

Hemispherical Spectral Emittance



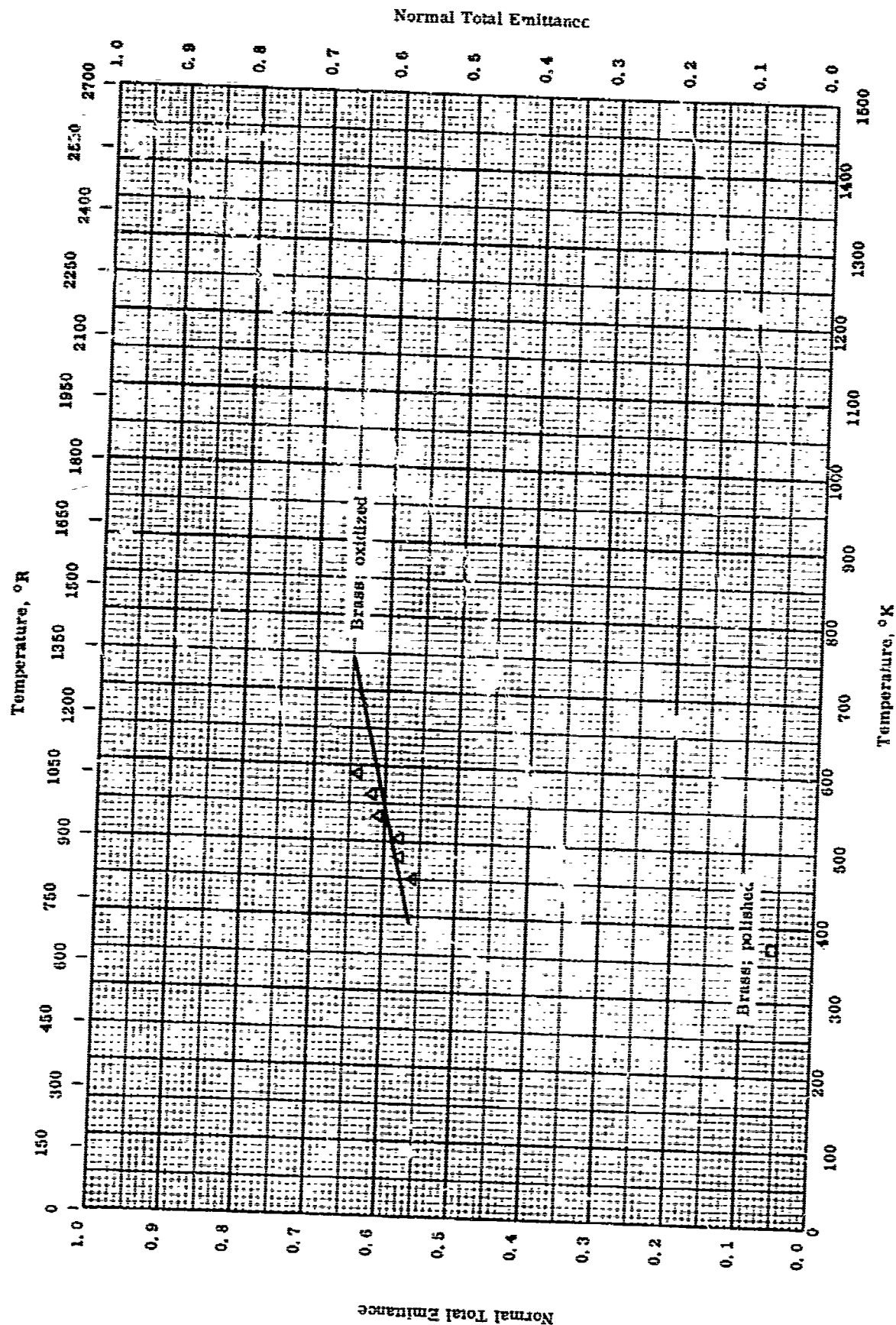
Wavelength, microns

HEMISPHERICAL SPECTRAL EMITTANCE --- COPPER - ZINC

HEMISPHERICAL SPECTRAL EMITTANCE --- COPPER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|---------------------|-------------------|------------------|-----------------------|--|
| O | 48-8 | 0.96 | 90 | < 20 | Brass. | Measured in vacuum (10^{-6} mm Hg) . |



TPRC

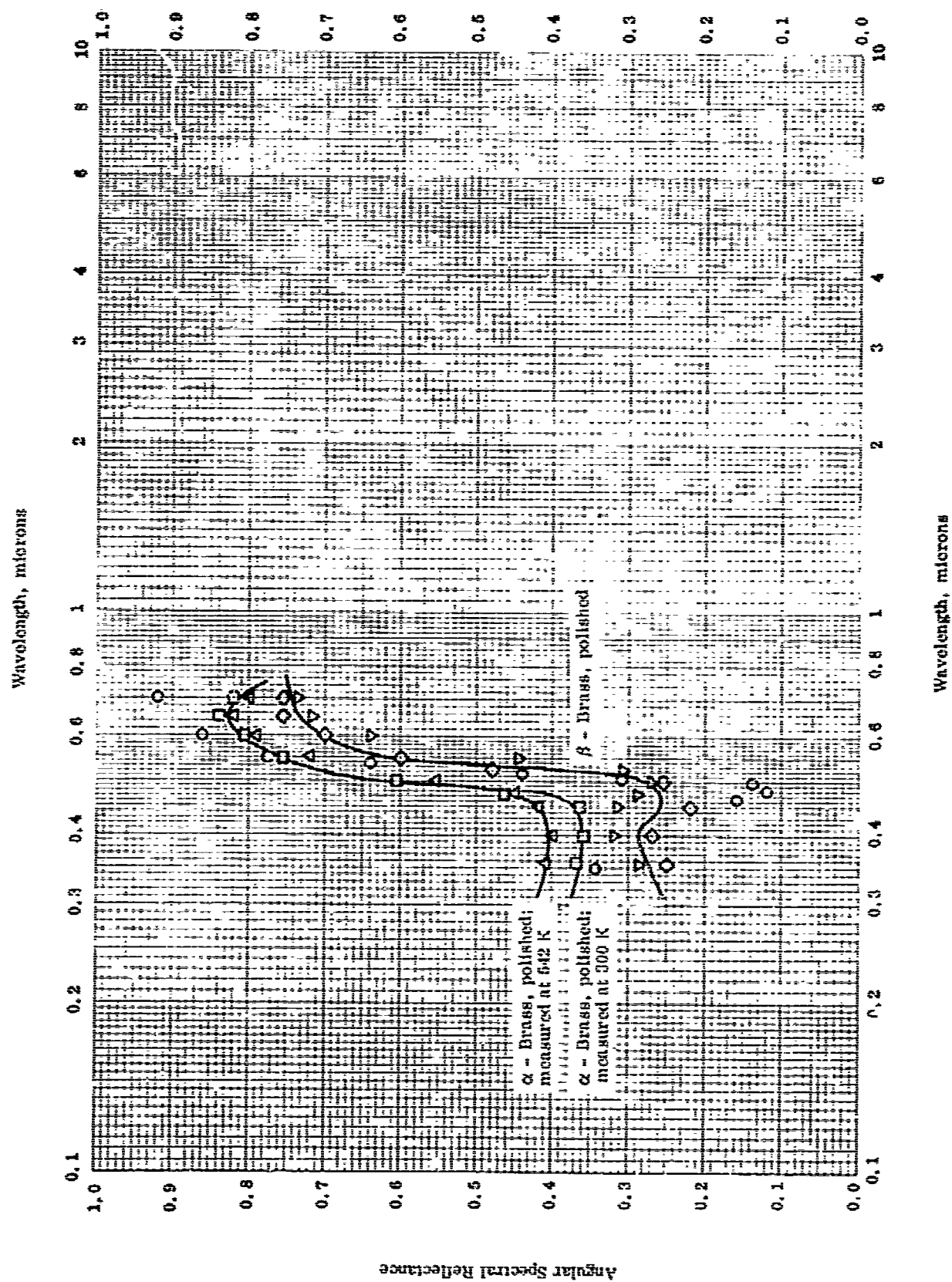
NORMAL TOTAL EMITTANCE -- CO₂ PER + ZINC

NORMAL TOTAL EMITTANCE -- COPPER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|-----------|
| △ | 58-23 | 450-580 | | Brass. | Oxidized. |
| □ | 47-5 | 373 | | Brass. | Polished. |

Angular Spectral Reflectance



ANGULAR SPECTRAL REFLECTANCE -- COPPER + ZINC

ANGULAR SPECTRAL REFLECTANCE -- COPPER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|-----------------|---------------------------------------|--|
| ○ | 61-24 | 298 | 0.35-0.70 | | β -brass; film 0.2 μ thick. | Vacuum evaporated on glass; 45 degree illumination, 45 degree viewing; data extracted from smooth curve. |
| △ | 57-40 | 542 | 0.3575-0.700 | | α -brass. | Polished; 18 degree illumination, hemispherical viewing; measured in dry nitrogen atmosphere. |
| □ | 57-40 | 300 | 0.3575-0.700 | | α -brass. | The above specimen measured at room temperature after the elevated temperature run; 18 degree illumination, hemispherical viewing. |
| ▽ | 57-40 | 548 | 0.350-0.700 | | β -brass. | Polished; 18 degree illumination, hemispherical viewing; measured in dry nitrogen atmosphere. |
| ◇ | 57-40 | 300 | 0.350-0.700 | | β -brass. | The above specimen measured at room temperature after the elevated temperature run; 18 degree illumination hemispherical viewing. |

PROPERTIES OF COPPER + ZIRCONIUM

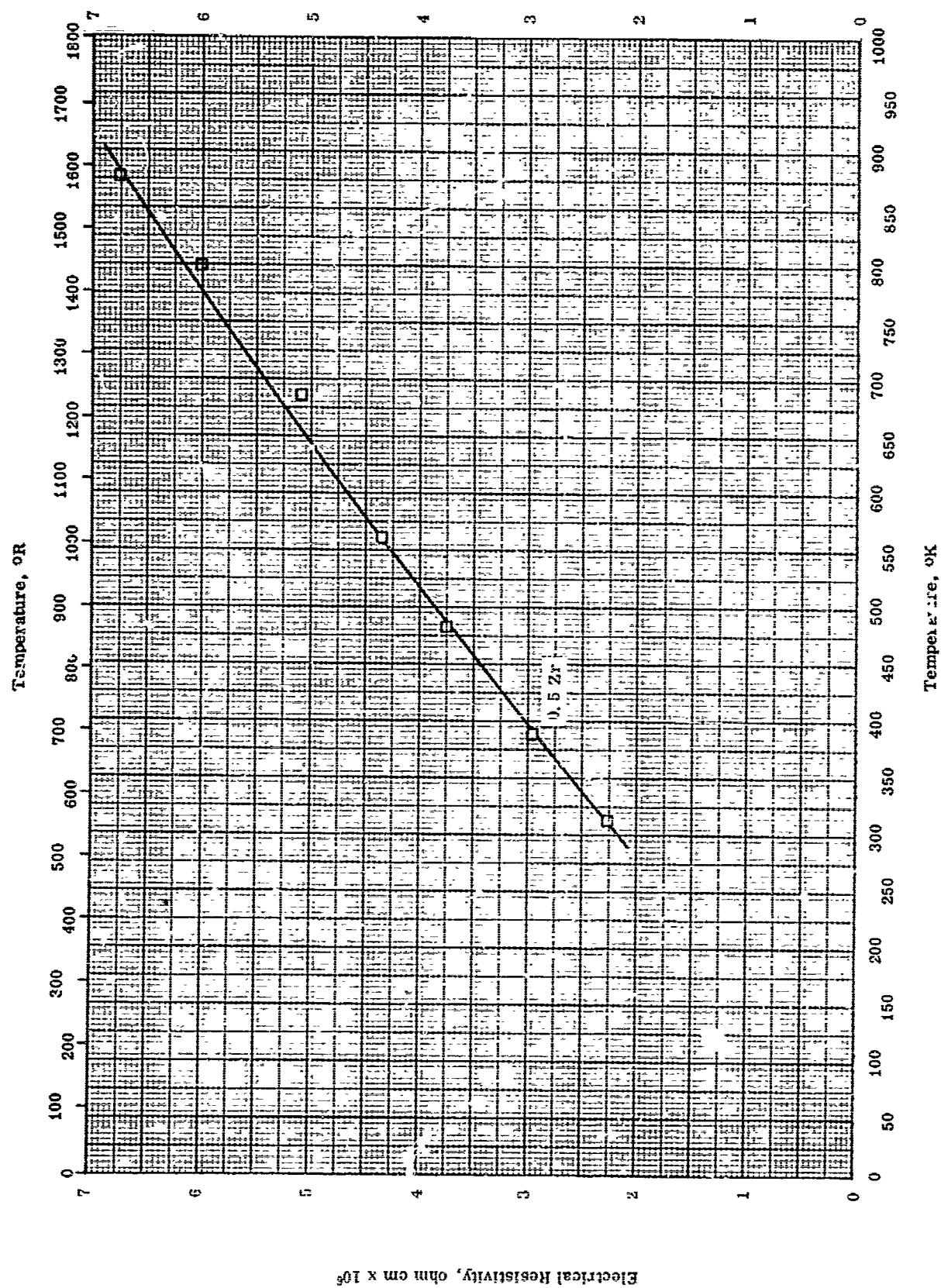
REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| O 0.8 Zr | 8.81 | 550 |

PROPERTIES OF COPPER + ZIRCONIUM

REFERENCE INFORMATION

| Ref. | Temp. Range °K | Relat. Error % | Sample Specifications | Remarks |
|-------|----------------|----------------|---|--|
| 57-44 | 298 | | 0.8 Zr; prepared from electrolytic Cu and pure Zr sponge. | Vacuum melted cast, pressed at 750 C, annealed 2 hrs at 650 C, furnace cooled, again annealed, and water quenched. |



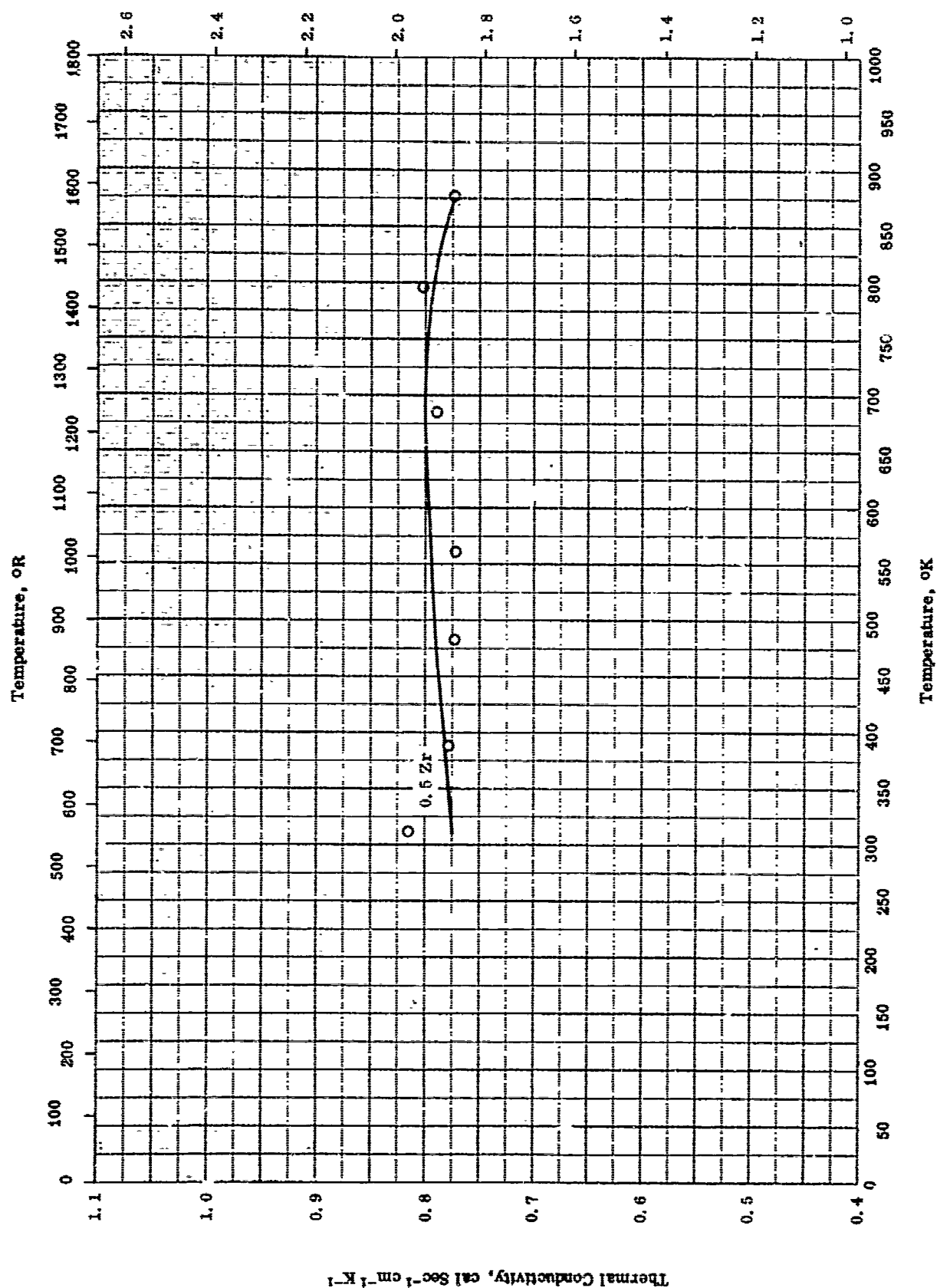
ELECTRICAL RESISTIVITY -- COPPER + ZIRCONIUM

TPRC

ELECTRICAL RESISTIVITY -- COPPER + ZIRCONIUM

REFERENCE INFORMATION

| Sym- bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|------|-------------------|------------------|-----------------------|-------------|
| □ | 59-6 | 313-879 | | 0.5 Zr. | Normalized. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$ 

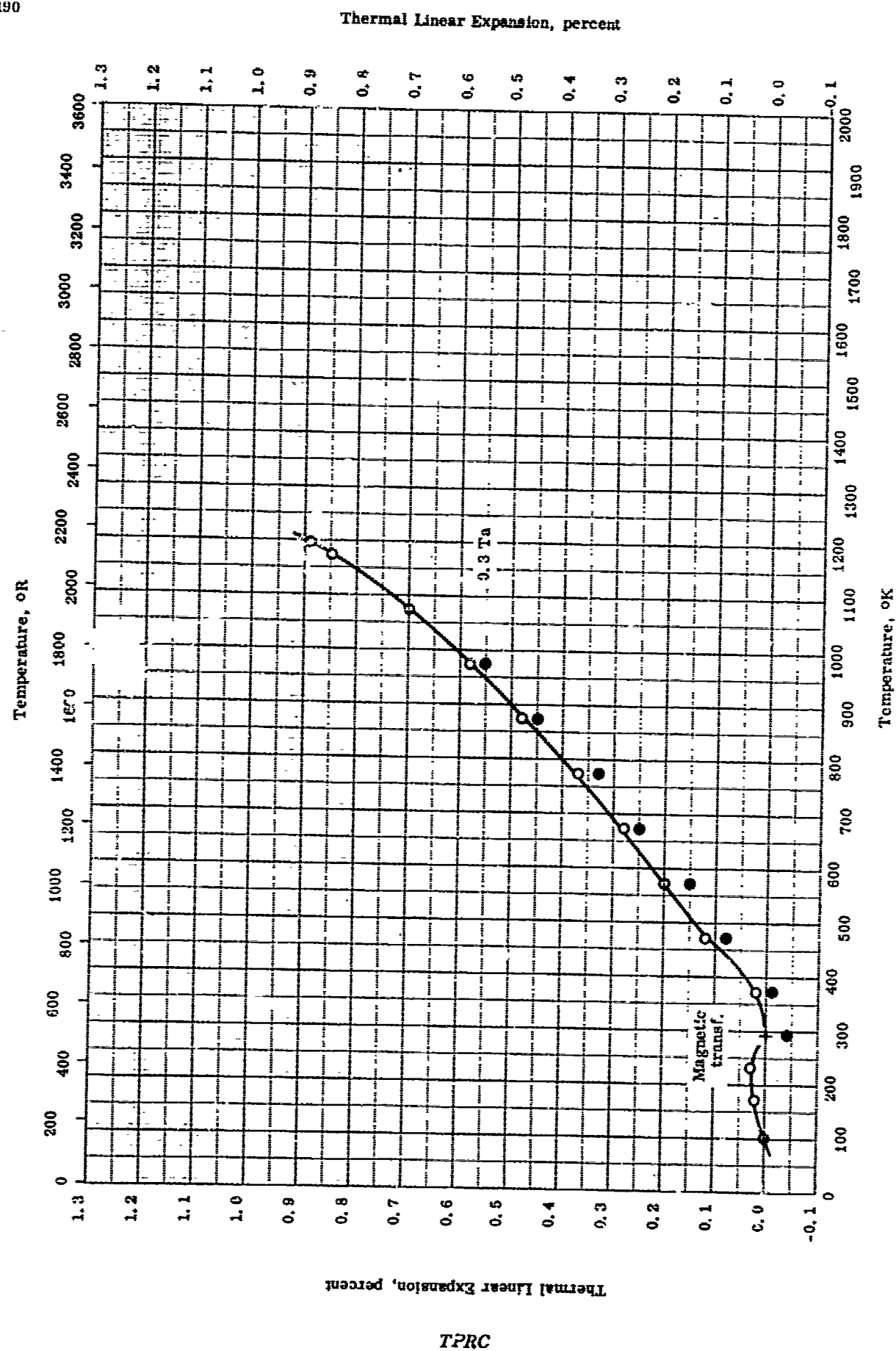
THERMAL CONDUCTIVITY -- COPPER + ZIRCONIUM

THERMAL CONDUCTIVITY -- COPPER + ZIRCONIUM

REFERENCE INFORMATION

| Sym DOI | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|-------------|
| O | 56-6 | 313-870 | | 0.5 2r. | Normalized. |

TPRC



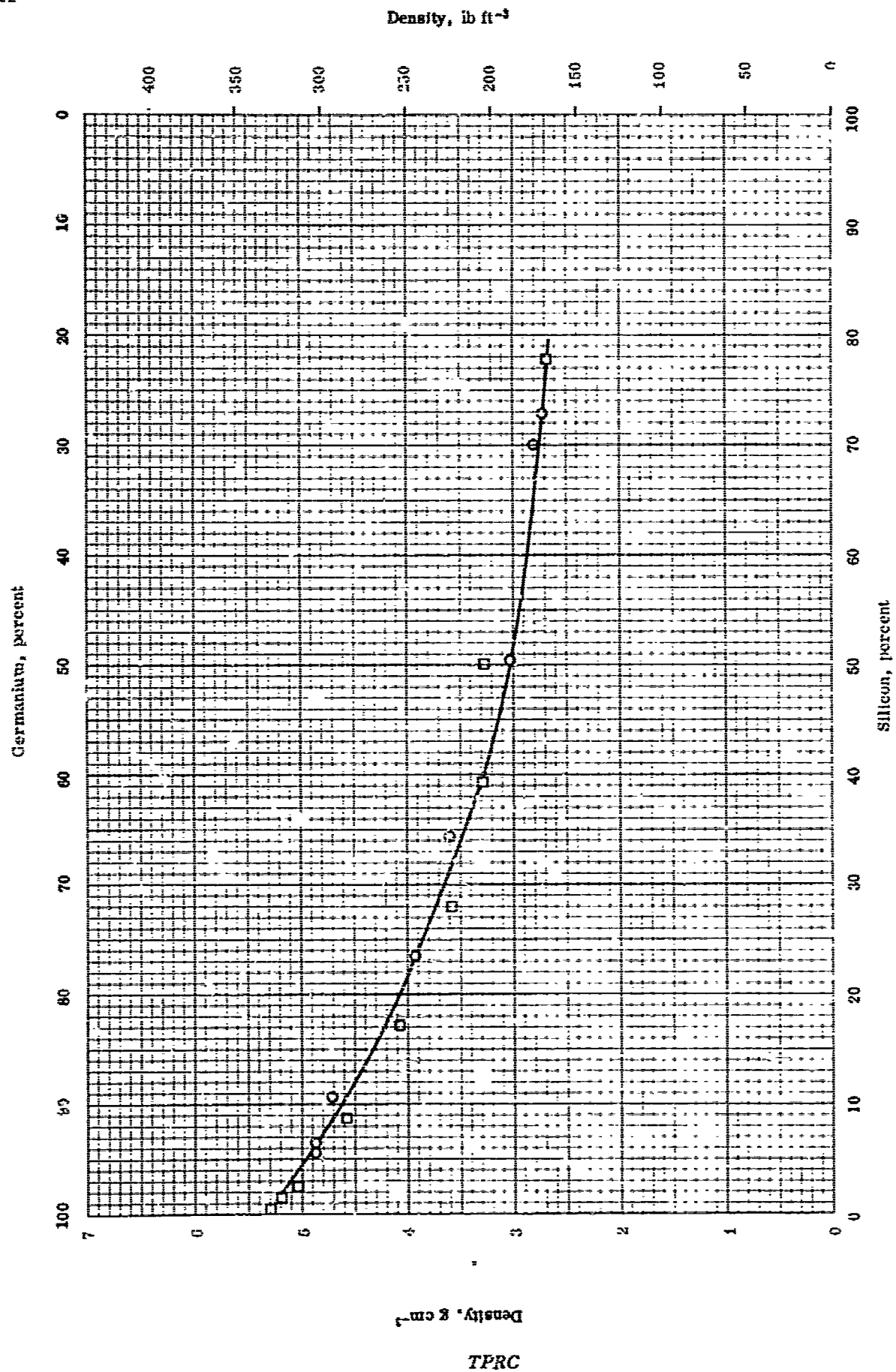
THERMAL LINEAR EXPANSION -- GADOLINIUM + TANTALUM

Thermal Linear Expansion -- Gadolinium + Tantalum

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|---|---|
| ○ | 56-42 also 57-51 | 103-1193 | ± 1 | 99.5 pure, 0.3 Ta, 0.64 Ca, and 0.01 Si, Fe, Mg each. | Ca reduced the fluoride, vacuum cast, recast into rod; tested in He; heating |
| ● | 57-51 | 293-1193 | ± 1 | Same as above. | The above specimen, cooling. |

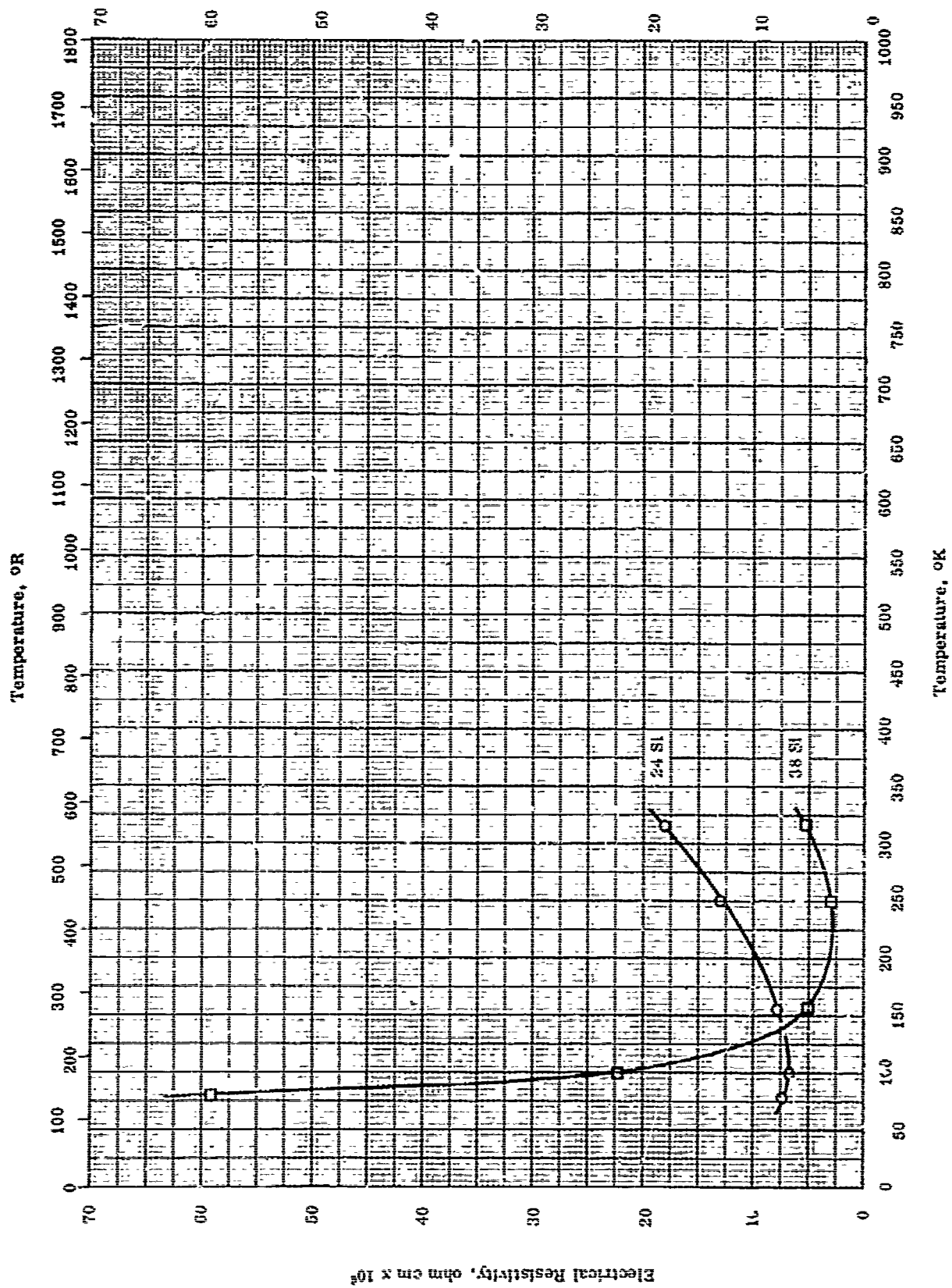
TPRC



DENSITY -- GERMANIUM + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| □ | 55-26 | 298 | | From zone-refined Ge and by hyper-pure Si. | Prepared by isothermal solidification. |
| ○ | 54-22 | 298 | | | Author claim accuracy of a few percent. |

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY --- GERMANIUM + SILICON

ELECTRICAL RESISTIVITY -- GERMANIUM + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 55-23 | 70-316 | | 76 Ge and 24 Si. | |
| □ | 55-23 | 70-316 | | 62.3 Ge and 37.7 Si. | |

PROPERTIES OF GOLD + CADMIUM

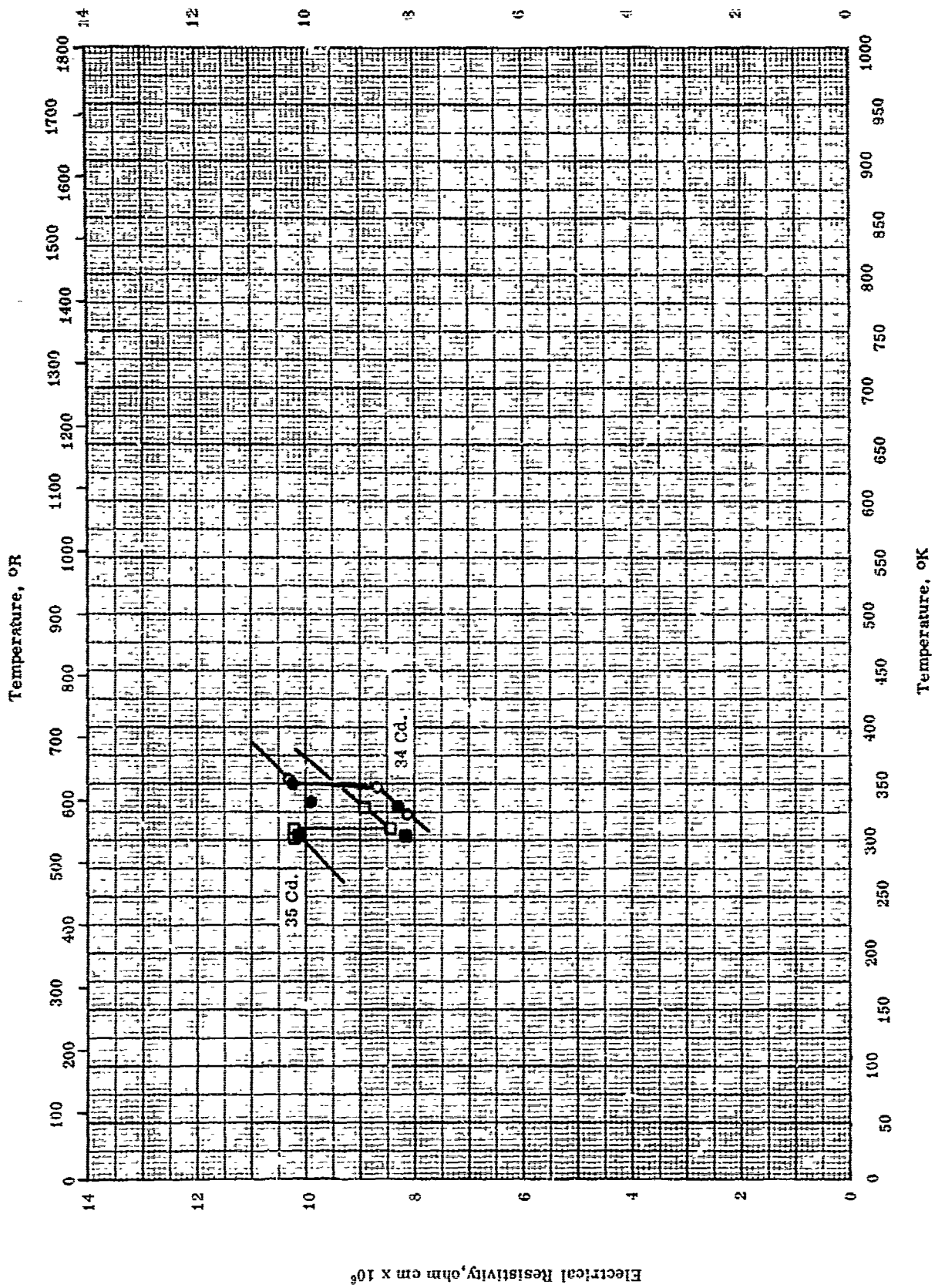
REPORTED VALUES

| Density | g cm^{-3} | lb ft^{-3} |
|----------------------------------|---------------------|----------------------|
| ○ 35.4 - 36.5 Cd; cubic phase | 13.96 | 871.5 |
| □ 35.4-36.5 Cd; tetragonal phase | 14.49 | 904.6 |
| △ 35.4 Cd | 13.911 | 868.44 |
| Melting Point | K | R |
| ◇ 36.3 Cd | 900 | 162 |
| Heat of Fusion | cal g^{-1} | Btu lb^{-1} |
| ▽ 36.3 Cd | 13.8 ± 0.8 | 24.9 ± 1.4 |

PROPERTIES OF GOLD + CADMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|---------------------------------|---|
| ○ | 54-17 | 208 | | 35.4-36.5 Cd; cubic phase. | Density by pycnometer. |
| □ | 54-17 | 318 | | 35.4-36.5 Cd; tetragonal phase. | Same as above. |
| △ | 57-39 | 298 | | 35.4 Cd. | Quenched from 500 C; density by weight in air and and in acetylene tetrabromide. |
| ◇ | 43-4 | 900 | | 36.3 Cd; β -phase. | Δh_f from enthalpy above and below M.P. |
| ▽ | 43-4 | 900 | | 36.3 Cd; β -phase. | |

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- GOLD + CADMIUM

TPRC

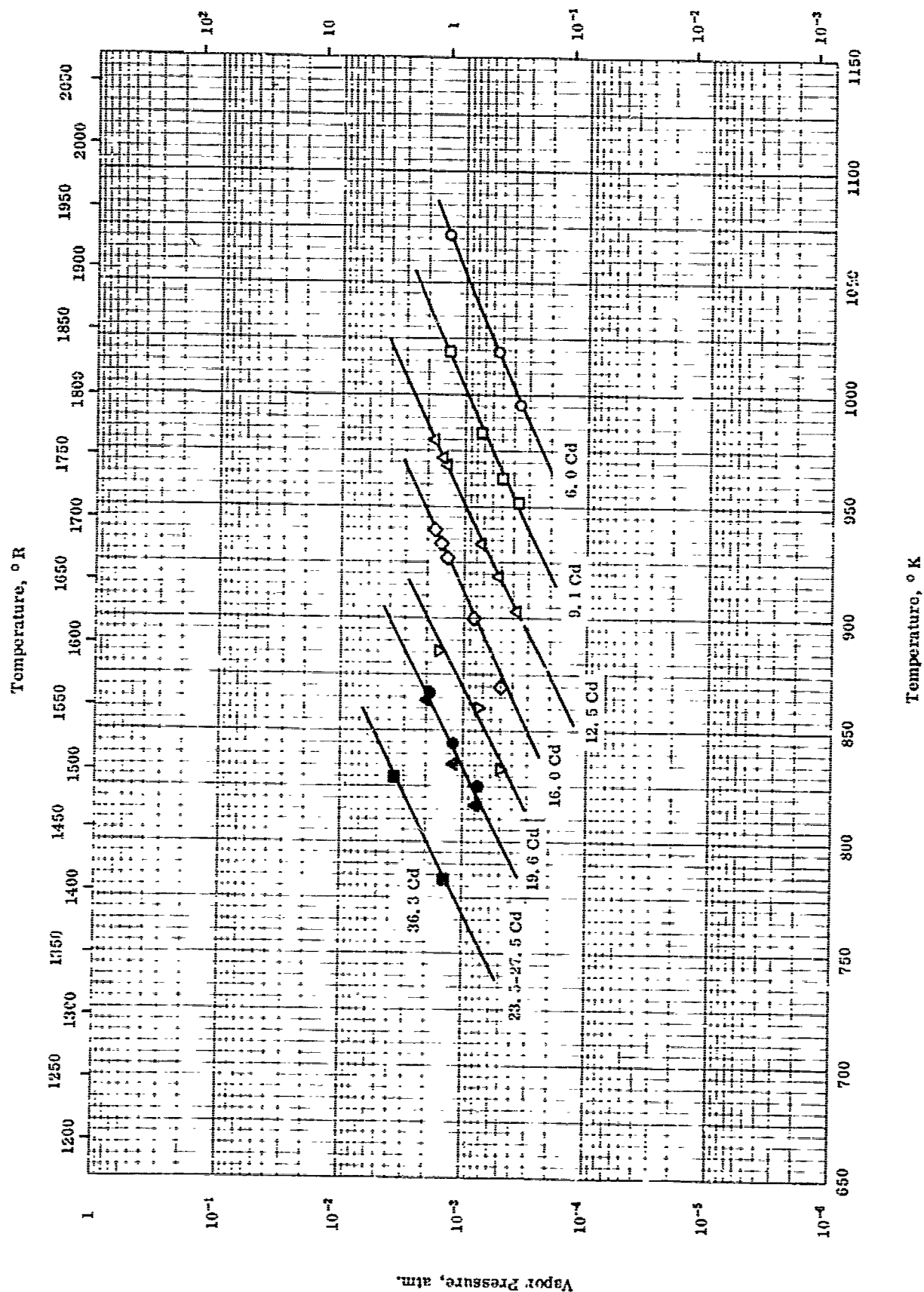
ELECTRICAL RESISTIVITY -- GOLD + CADMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| ○ | 54-17 | 323-353 | | 65.97 Au and 34.03 Cd; single crystal prepared from 99.95 Au and 99.99 Cd. | Vacuum-melted and grown into single crystal; measured heating. |
| ● | 54-17 | 323-353 | | Same as above. | Same as above except measured cooling. |
| □ | 54-17 | 301-333 | | 64.61 Au and 35.39 Cd; same as above. | Same as above except data reported for third run; measured heating |
| ■ | 54-17 | 301-333 | | Same as above. | Same as above; measured cooling. |

TPRC

Vapor Pressure, mm Hg



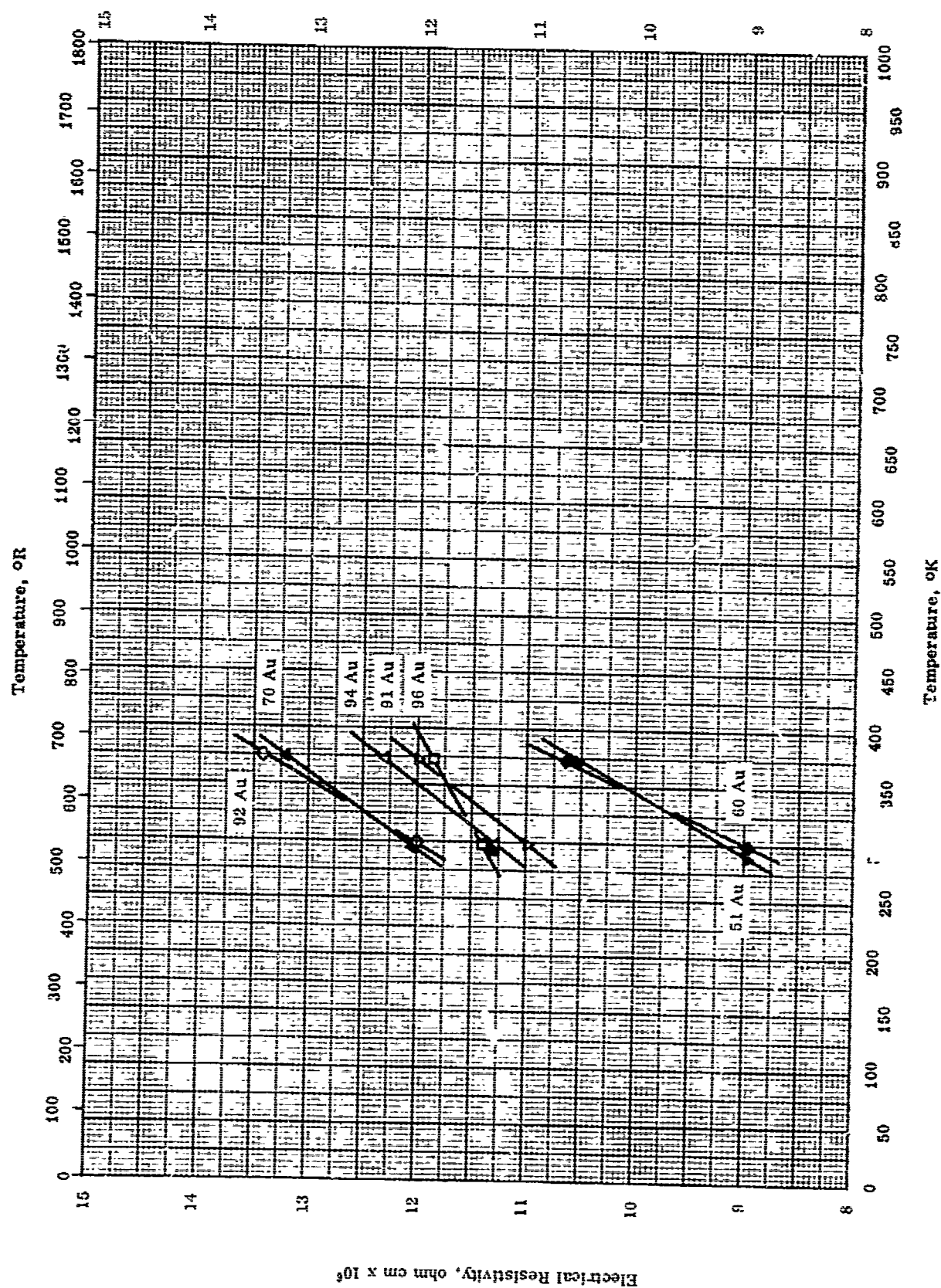
VAPOR PRESSURE -- GOLD + CADMIUM

VAPOR PRESSURE -- GOLD + CADMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|----------------------------------|---|
| ○ | 55-9 | 996-1073 | | 6.0 Cd; α -phase. | Data are pressure of Cd vapor over the alloy. |
| □ | 55-9 | 996-1073 | | 9.1 Cd; α -phase. | Same as above. |
| △ | 55-9 | 996-1073 | | 12.5 Cd; α -phase. | Same as above. |
| ◇ | 55-9 | 996-1073 | | 16.0 Cd; α -phase. | Same as above. |
| ▽ | 55-9 | 996-1073 | | 19.6 Cd; α -phase. | Same as above. |
| ● | 55-9 | 996-1073 | | 23.5 Cd; α -ph. 12. | Same as above. |
| ▲ | 55-9 | 996-1073 | | 27.5 Cd; $\alpha + \beta$ phase. | Same as above. |
| ■ | 55-9 | 996-1073 | | 36.3 Cd; β -phase. | Same as above. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- GOLD + COBALT

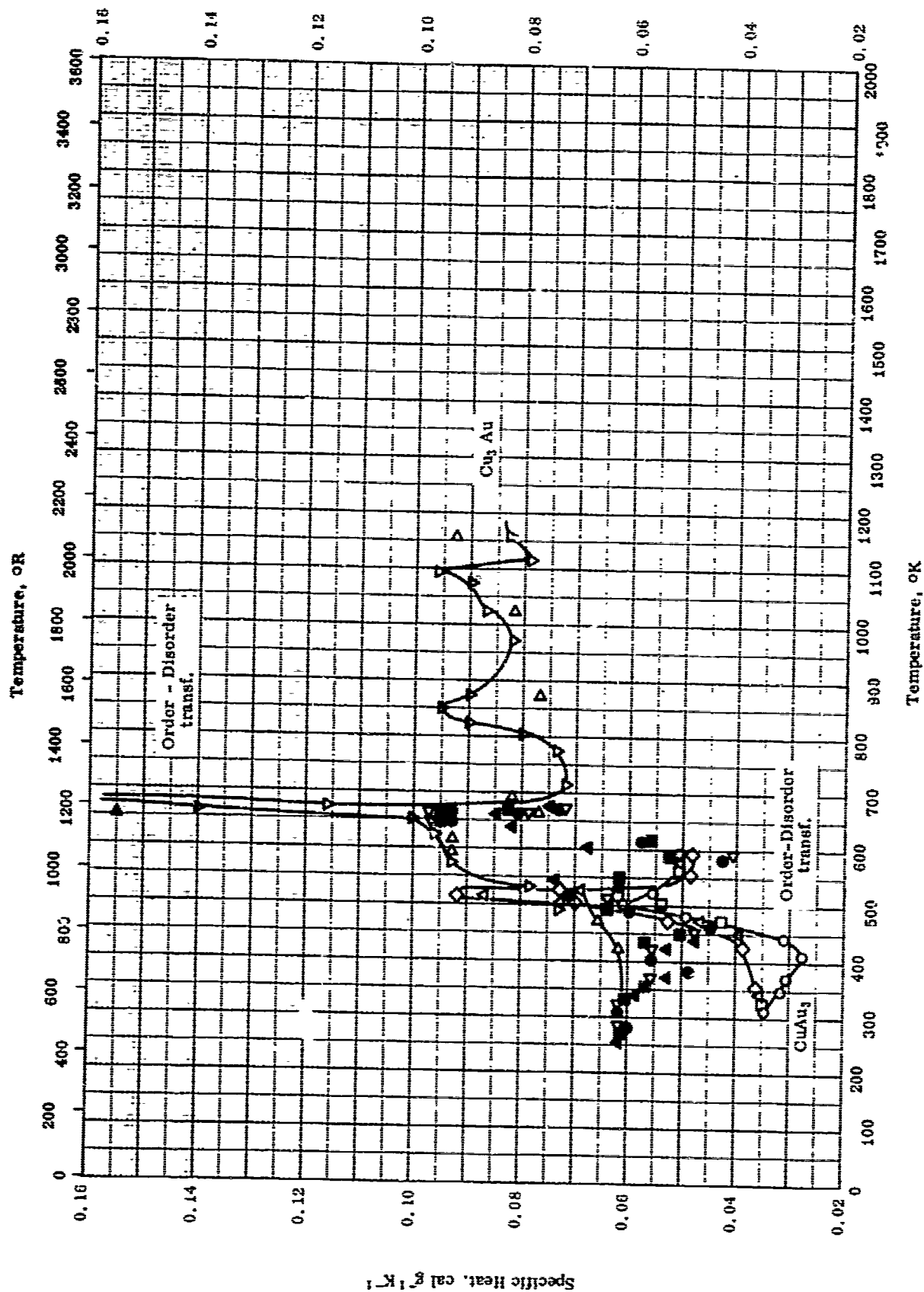
TPRC

ELECTRICAL RESISTIVITY -- GOLD + COBALT

REFERENCE INFORMATION

| Sym bol | r | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| □ | 56-33 | 298-373 | | 96.0 Au, and 4.0 Co; initial elements 99.99 pure. | Sample prepared by sucking liquid alloy into a porcelain tube. |
| △ | 56-33 | 298-373 | | 93.6 Au, and 6.4 Co; same as above. | Same as above. |
| ◇ | 56-33 | 298-373 | | 92.0 Au, and 8.0 Co; same as above. | Same as above. |
| ▽ | 56-33 | 298-373 | | 91.2 Au, and 8.8 Co; same as above. | Same as above. |
| ■ | 56-33 | 298-373 | | 80.0 Au, and 20.0 Co; same as above. | Same as above. |
| ▲ | 56-33 | 298-373 | | 70.2 Au, and 29.8 Co; same as above. | Same as above. |
| ◆ | 56-33 | 298-373 | | 60.0 Au, and 40.0 Co; same as above. | Same as above. |
| ▼ | 56-33 | 298-373 | | 51.2 Au, and 48.8 Co; same as above. | Same as above. |

TPRC

Specific Heat, $\text{Btu lb}^{-1} \text{R}^{-1}$ 

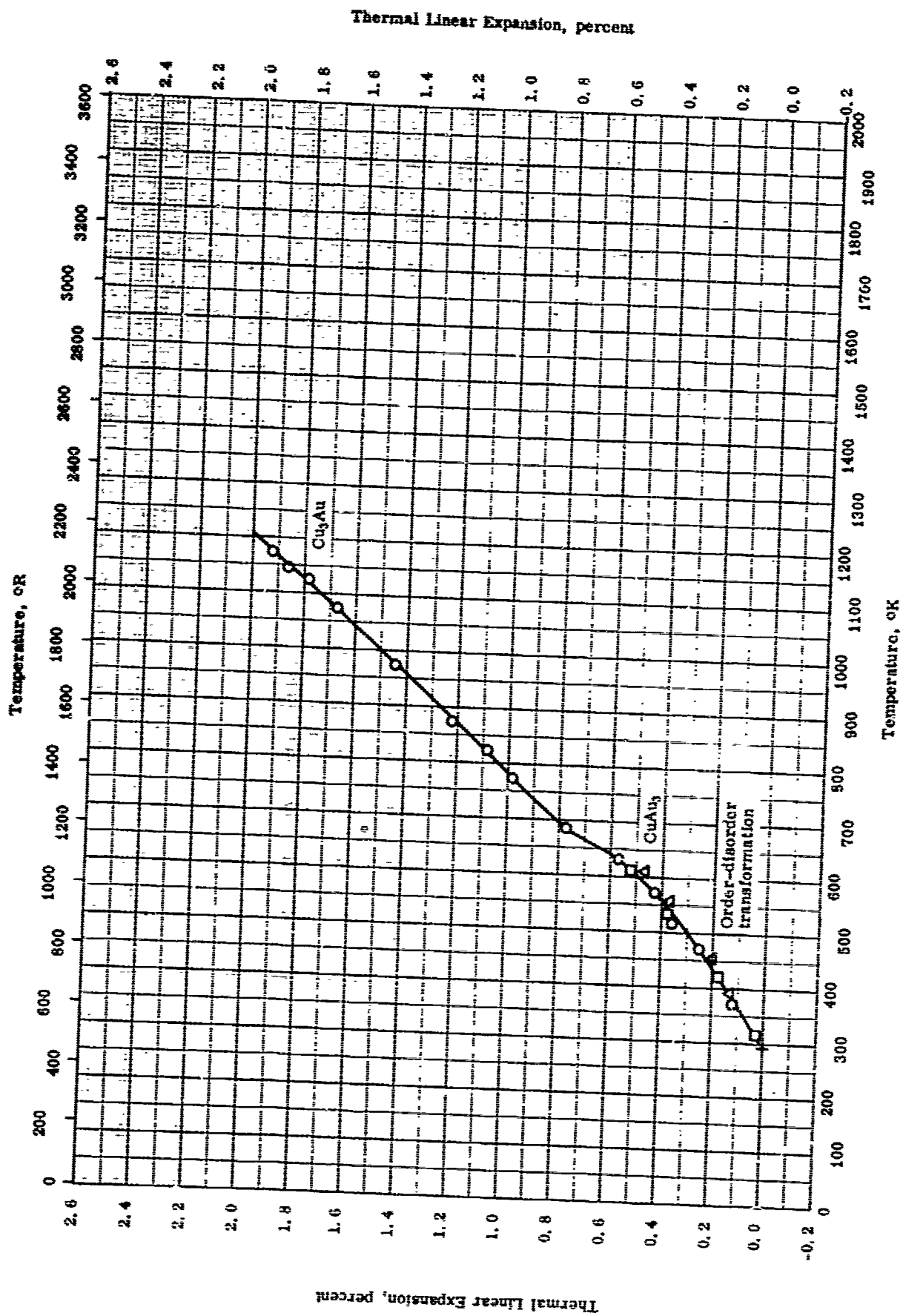
SPECIFIC HEAT -- GOLD + COPPER

TPRC

SPECIFIC HEAT -- GOLD + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rep. Error % | Sample Specifications | Remarks |
|------------|----------------------|-------------------|-----------------|---|---|
| ○ | 51-9 also 52-7 | 313-573 | | Cu Au ₃ ; 89.8 Au and 10.2 Cu. | Reheated slowly after water quenched from 600 C. |
| □ | 51-9 also 52-7 | 313-573 | | Same as above. | Air cooled before reheating. |
| △ | 51-9 also 52-7 | 313-573 | | Same as above. | Annealed 180 C for several days. |
| ◇ | 51-9 also 52-7 | 313-573 | | Same as above. | Same as above. |
| ▽ | 50-14 | 403-1173 | | Cu ₂ Au; 50.7 Au and 49.3 Cu; made from 99.98 Au and 99.97 Cu. | Swaged into rods and heat treated just below melting point for 10 days. |
| △ | 57-15 | 288-1158 | | Cu ₂ Au; 50.7 Au and 49.3 Cu; ordered. | Annealed 3 weeks at 420-200 C. |
| ▽ | 57-15 | 288-1158 | | Same as above. | Quenched from 530 C. |
| ● | 57-15 | 288-1158 | | Same as above. | Quenched from 600 C. |
| ■ | 57-15 | 288-1158 | | Same as above. | Quenched from 670 C. |
| ▲ | 57-15 | 288-1158 | | Same as above. | Quenched from 790 C. |



THERMAL LINEAR EXPANSION -- GOLD + COPPER

THERMAL LINEAR EXPANSION -- GOLD + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| O | 50-41 | 293-1173 | | Cu ₃ Au; 50.8 Au and 49.2 Cu; prepared from 99.986 Au and 99.97 Cu. | Melted in evacuated quartz tube from Au and Cu; swaged into rods and then heat treated 10 days just below melting point. |
| □ | 52-7 | 293-613 | | Cu Au ₃ ; 90 Au and 10 Cu. | Annealed 14 days at 180 C. |
| △ | 52-7 | 293-613 | | Same as above. | Water quenched from 400 C. |

PROPERTIES OF GOLD + IRON

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| O 9.86 Fe | 16.29 | 1017 |

PROPERTIES OF GOLD + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|--|
| O | 43-5 | 208 | | 90.14 Au and 0.86 Fe. | Fe added to melted Au in H ₂ atm; cast; remelted, and quenched from 850 C. |

PROPERTIES OF GOLD + MANGANESE

REPORTED VALUES

| Density | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| ○ 8.59 Mn | 15.86 | 990 |

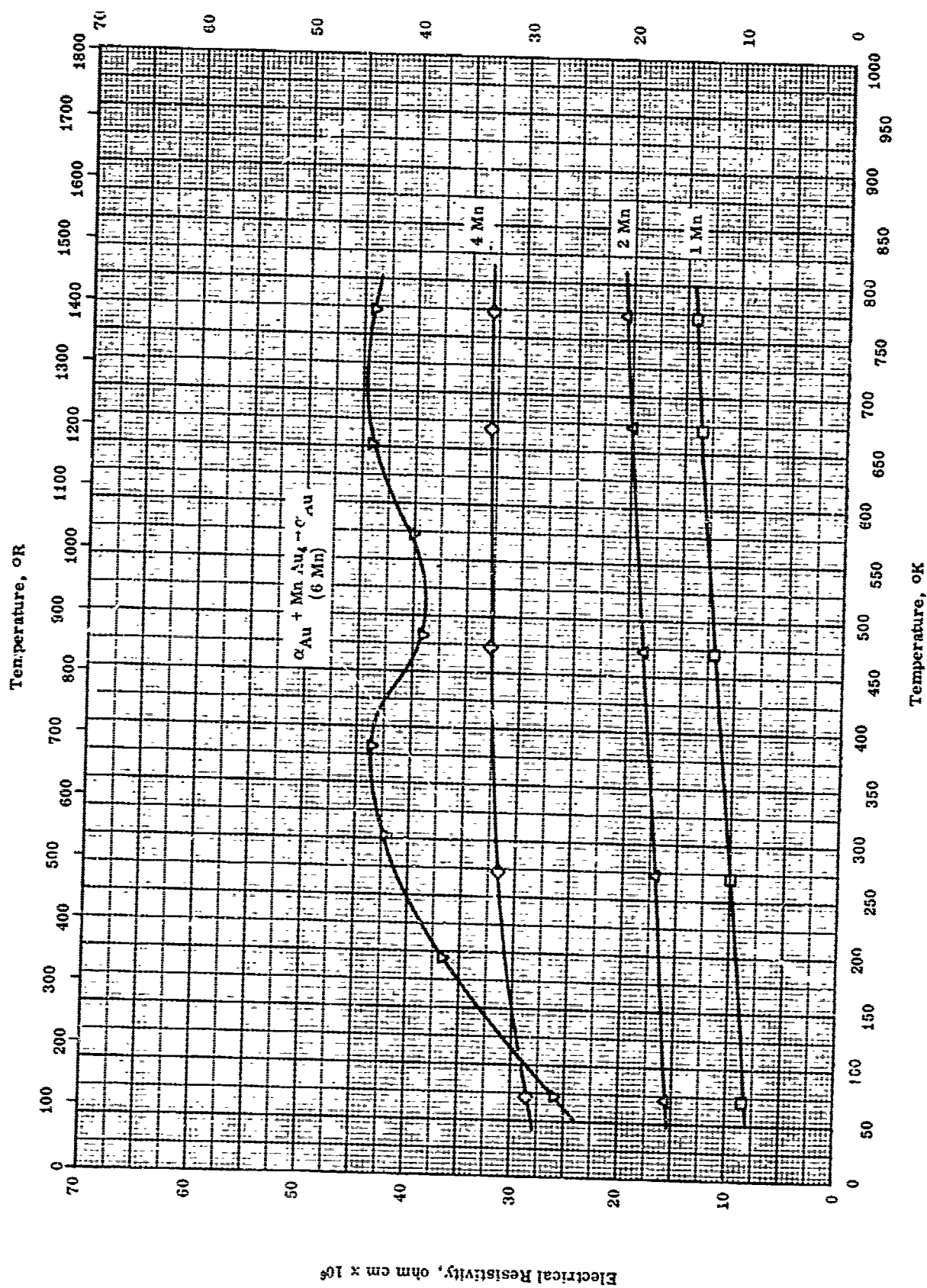
TPRC

PROPERTIES OF GOLD + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|--|
| O | 43-5 | 298 | | 91.41 Au and 8.59 Mn. | Mn added to melted Au in H ₂ atm; cast, remelted, and quenched from 850 C. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$ 

ELECTRICAL RESISTIVITY -- GOLD + MANGANESE

TPRC

ELECTRICAL RESISTIVITY -- GC LD + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| □ | 56-26 | 73-773 | | 1. 00 Mn; prepared from 99.99 pure raw materials. | Heated to 100 C above MP in vacuum, homogenized 24 hrs at 900 C, swaged, and annealed 1 hr at 500 C. |
| △ | 56-26 | 73-773 | | 2. 00 Mn; raw materials same as above. | Same as above. |
| ◇ | 56-26 | 73-773 | | 4. 00 Mn; raw materials same as above. | Same as above. |
| ▽ | 56-26 | 73-773 | | 6. 00 Mn; raw materials same as above. | Same as above. |

TPRC

PROPERTIES OF GOLD + NICKEL.

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|------------|--------------------|---------------------|
| ○ 5.13 Ni | 18.07 | 1128 |
| □ 10.26 Ni | 17.06 | 1065 |

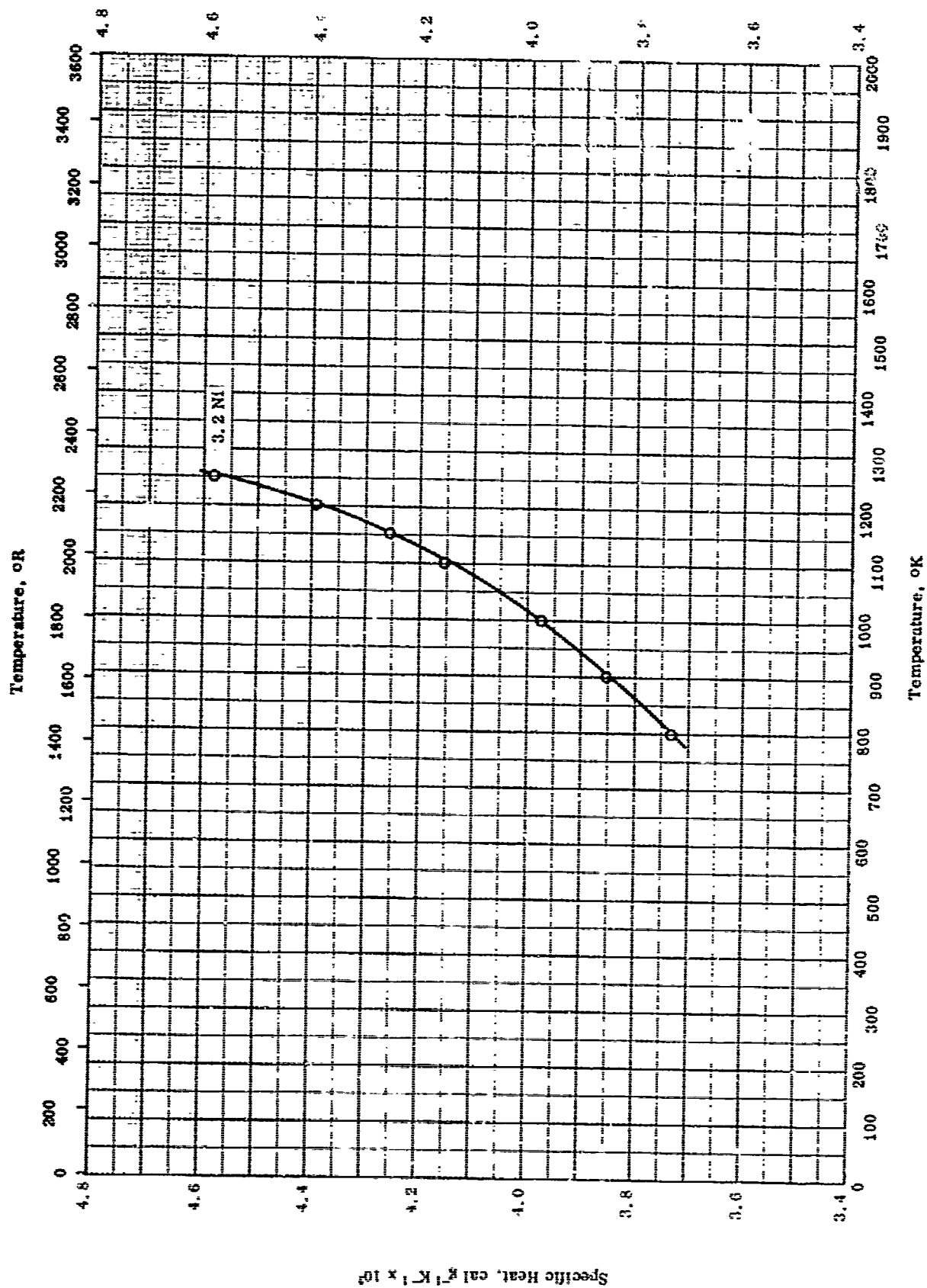
TPRC

PROPERTIES OF GOLD + NICKEL

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|------------------------|---|
| ○ | 43-5 | 298 | | 94.87 Au and 5.13 Ni. | Ni added to melted Au in H ₂ atm ; cast, remelted, and quenched from 850 C. |
| □ | 43-5 | 298 | | 89.74 Au and 10.26 Ni. | Same as above. |

TPRC

Specific Heat, $\text{Btu lb}^{-1} \text{R}^{-1} \times 10^3$ 

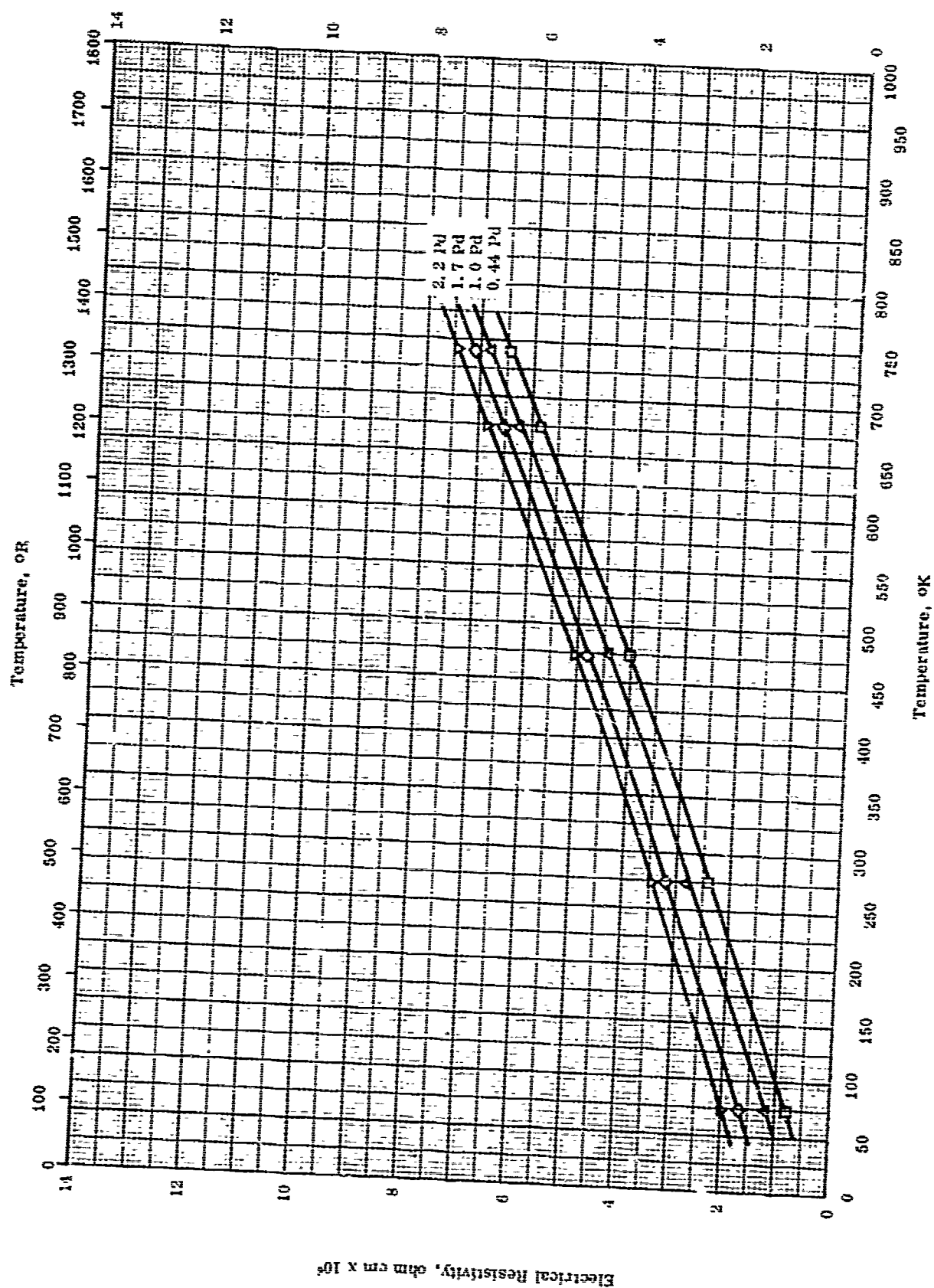
SPECIFIC HEAT -- GOLD + NICKEL.

TPRC

SPECIFIC HEAT -- GOLD + NICKEL.

REFERENCE INFORMATION

| Sym [Sol] | Ref. | Temp. Range °K | Expt. Error % | Sample Specifications | Remarks |
|--------------|-------|-------------------|------------------|--|--|
| O | G2-13 | 800-1250 | | Au _{99.99} Ni _{0.01} ; 86.8 Au, 3.2 Ni; prepared from 99.95 Au and Ni. | Homogenized for more than 1 week above 50 C. |

Electrical Resistivity, ohm cm $\times 10^5$ 

ELECTRICAL RESISTIVITY — GOLD + PALLADIUM

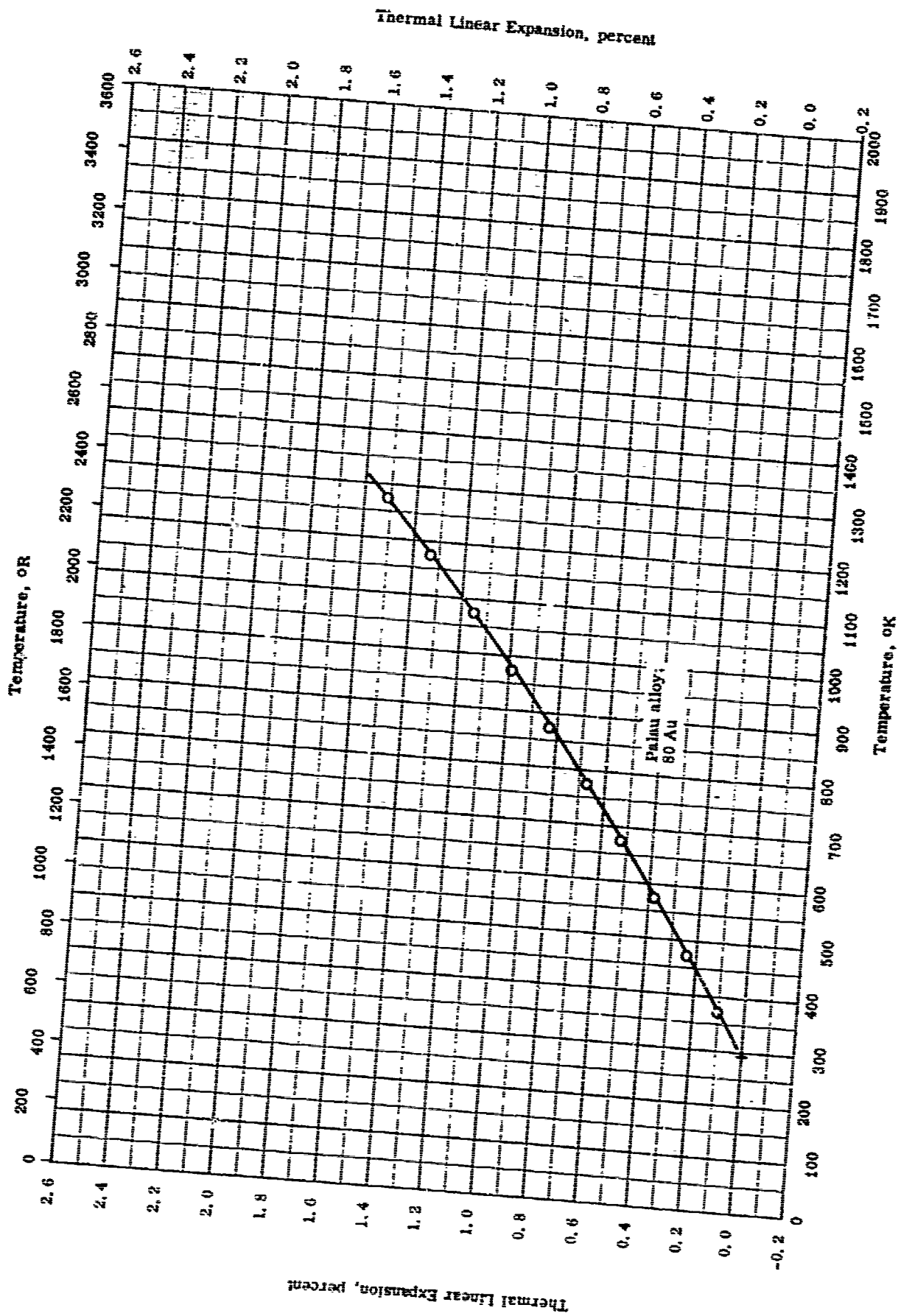
TPRC

ELECTRICAL RESISTIVITY --- GOLD + PALLADIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| □ | 56-26 | 73-1073 | | 0.44 Pd, prepared from 99.99 pure raw materials. | Heated to 100 C above MP, homogenized 24 hrs at 900 C, swaged, annealed 1 hr at 500 C. |
| △ | 56-20 | 73-1073 | | 1.0 Pd, raw materials same as above. | Same as above. |
| ◇ | 56-26 | 73-1073 | | 1.7 Pd, raw materials same as above. | Same as above. |
| ▽ | 56-26 | 73-1073 | | 2.2 Pd, raw materials same as above. | Same as above. |

TPRC



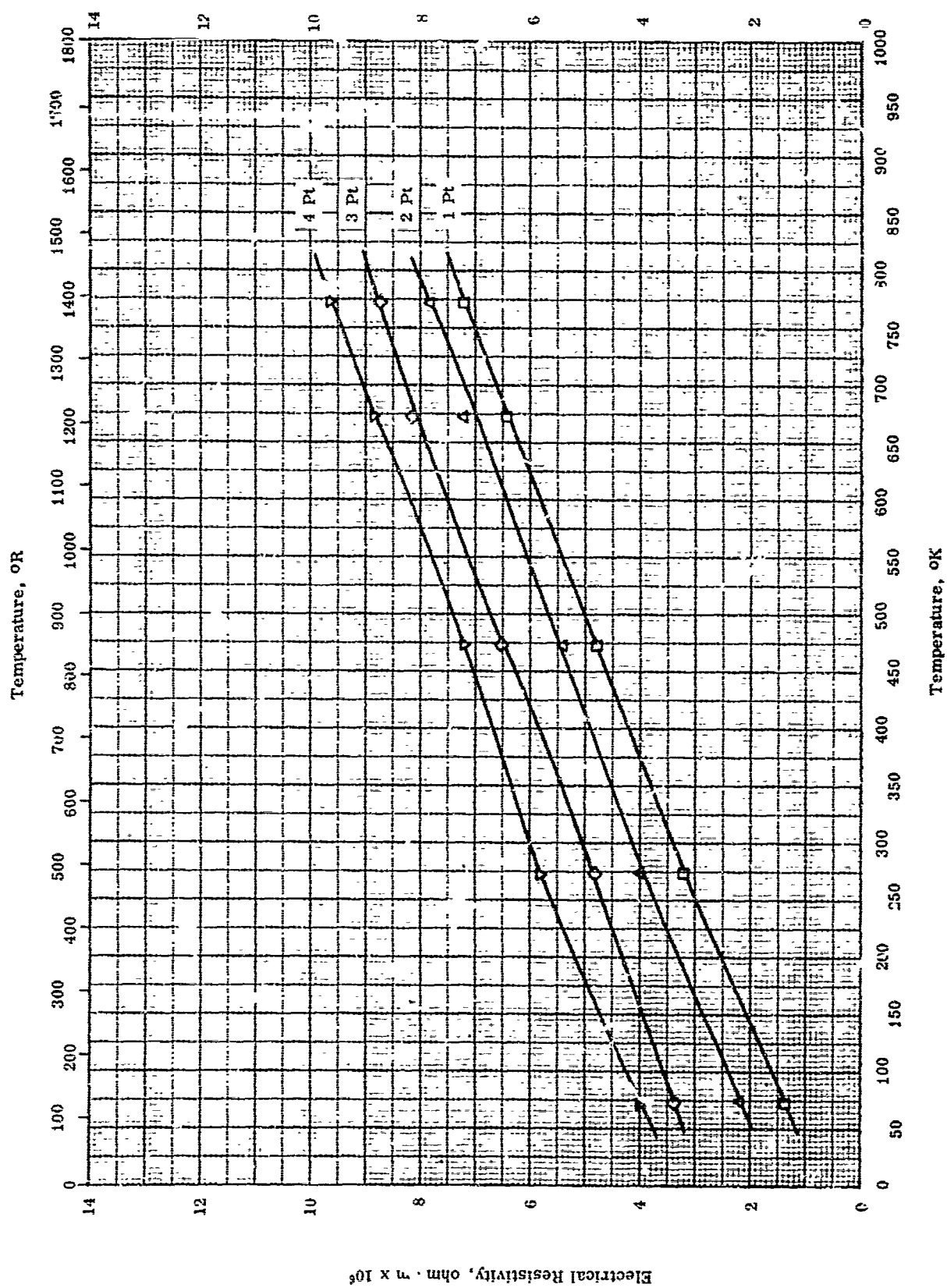
THERMAL LINEAR EXPANSION -- GOLD + PALLADIUM

THERMAL LINEAR EXPANSION -- GOLD + PALLADIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------------------|---------|
| ○ | 04-9 | 273-1273 | | Palladium alloy: 80 Au and 20 Pd. | |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$ 

TPRC

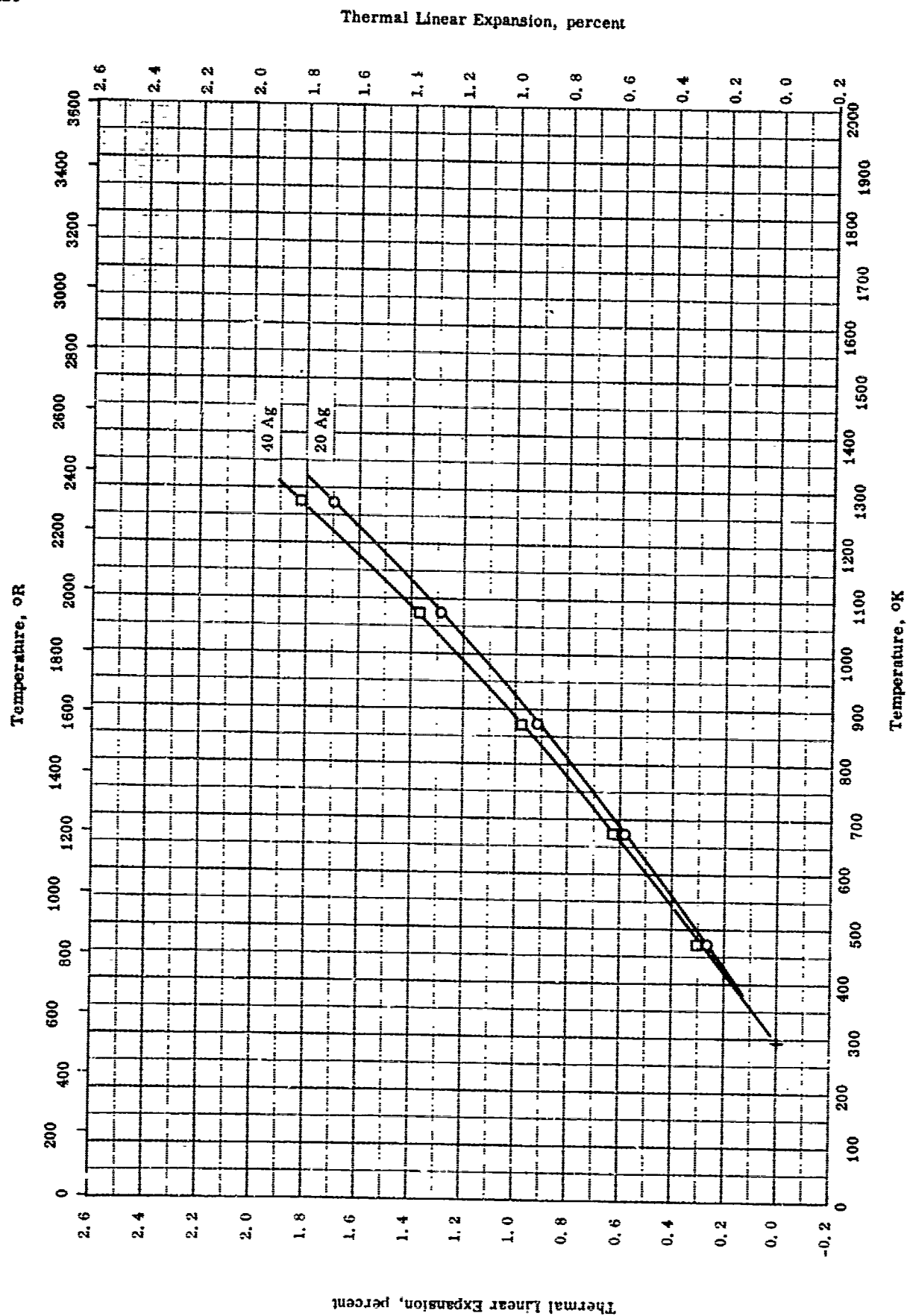
ELECTRICAL RESISTIVITY - GOLD - PLATINUM

ELECTRICAL RESISTIVITY -- GOLD + PLATINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| □ | 56-26 | 73-773 | | 1.0 Pt; prepared from 99.99 pure metals. | Vacuum melted 100 C above M.P from pure metals, homogenized 24 hrs at 900 C, swaged to 0.030 in. dia., and annealed 1 hr at 500 C. |
| △ | 56-26 | 73-773 | | 2.00 Pt; same as above. | Same as above. |
| ◇ | 56-26 | 73-773 | | 3.1 Pt; same as above. | Same as above. |
| ▽ | 56-26 | 73-773 | | 4.0 Pt; same as above. | Same as above. |

TPRC



TPRC

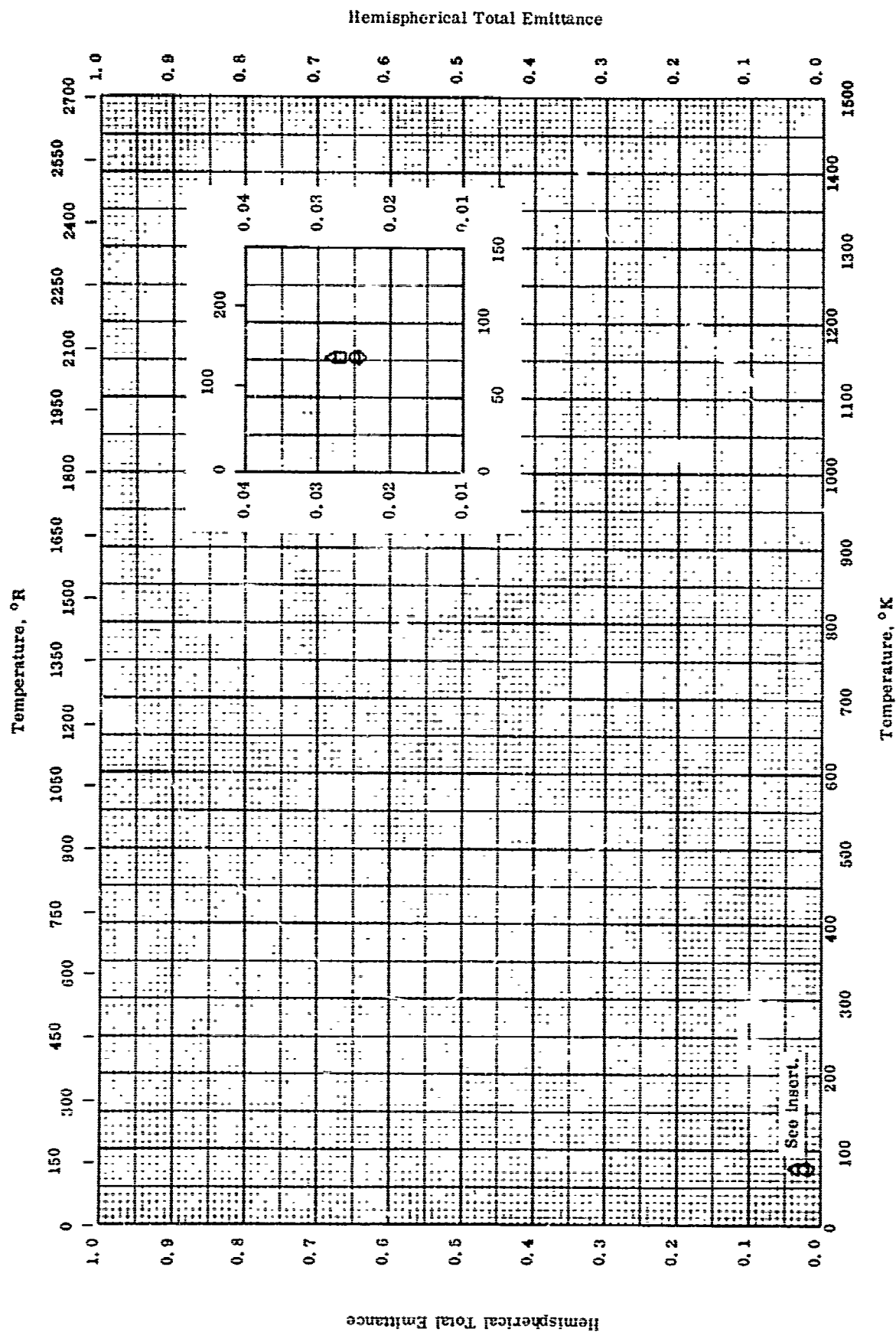
THERMAL LINEAR EXPANSION -- GOLD + SILVER

THERMAL LINEAR EXPANSION -- GOLD + SILVER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------------|
| ○ | 51-17 | 293-1273 | | 80 Au and 20 Ag. | Homogenized. |
| □ | 51-17 | 293-1275 | | 60 Au and 40 Ag. | Same as above. |

TPRC



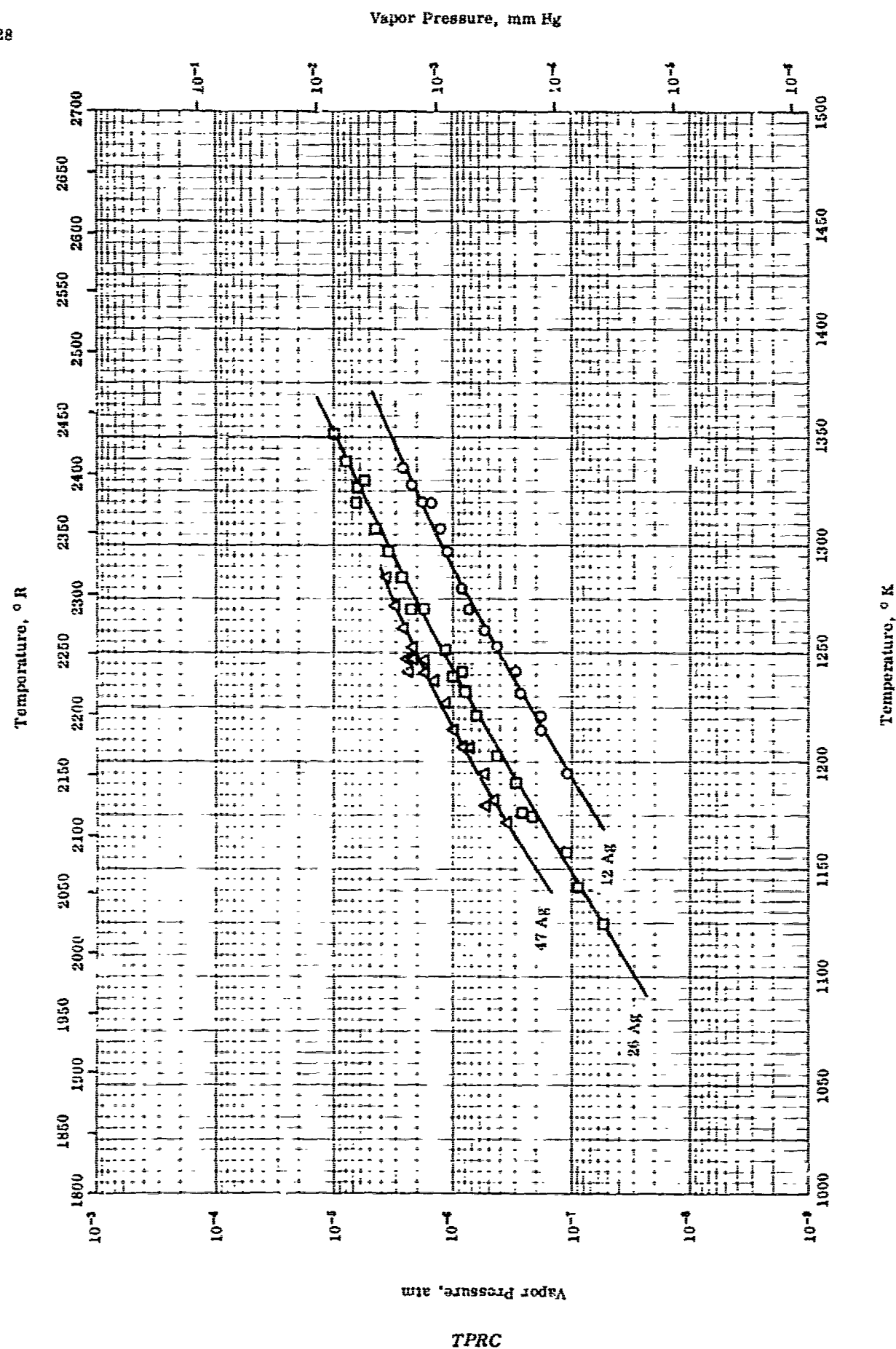
HEMISPHERICAL TOTAL EMITTANCE -- GOLD + SILVER

HEMISPHERICAL TOTAL EMITTANCE -- GOLD + SILVER

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 60-17 | 76 | 5 | 1 Ag. | 0.0602 in. gold plated on stainless steel; emittance for 300 K black body radiation. |
| □ | 60-17 | 76 | 5 | 1 Ag. | 0.0001 in. gold plated on stainless steel; emittance for 300 K black body radiation. |
| △ | 60-17 | 76 | 5 | 1 Ag. | 0.00005 in. gold plated on stainless steel; emittance for 300 K black body radiation. |
| ◇ | 60-17 | 76 | 5 | 1 Ag. | 0.0002 in. gold plated on copper; emittance for 300 K black body radiation. |

TPRC



VAPOR PRESSURE -- GOLD + SILVER

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 53-10 | 1195-1336 | | 88.3 Au and 11.7 Ag. | |
| □ | 53-10 | 1127-1354 | | 74.2 Au and 25.8 Ag. | |
| △ | 53-10 | 1173-1285 | | 52.8 Au and 47.2 Ag. | |

TPRC

PROPERTIES OF GOLD + URANIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| O 9.32 U | 18.60 | 1161 |

PROPERTIES OF GOLD + URANIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rpt. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|-----------------|-----------------------|--|
| O | 43-5 | 200 | | 90.68 Au and 9.32 U. | U added to melted Au in H ₂ atm; remelted, and quenched from 850 C. |

TPRC

PROPERTIES OF GOLD+ZINC

REPORTED VALUES

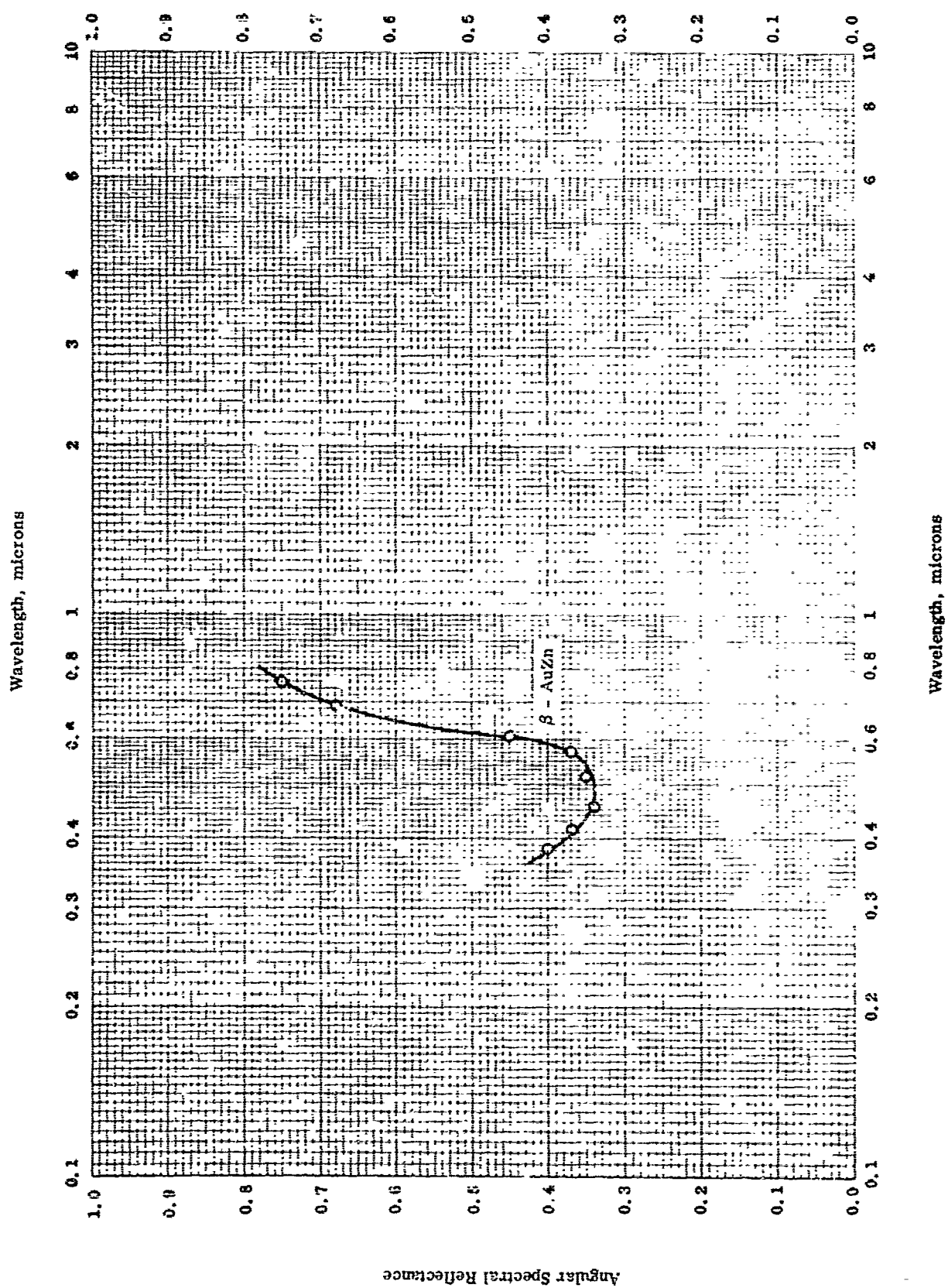
| Melting Point | K | R |
|----------------|---------------------|----------------------|
| □ 24.9 Zn | 1033 | 1860 |
| Heat of Fusion | cal g ⁻¹ | Btu lb ⁻¹ |
| ○ 24.9 Zn | 22.4 ± 1 | 40.3 ± 1.8 |

PROPERTIES OF GOLD + ZINC

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Expt. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---------------------------|--|
| ○ | 43-4 | 1033 | | 24.9 Zn; β - phase. | ΔH from enthalpy data above and below M.P. |
| □ | 43-4 | 1033 | | 24.0 Zn β - phase | |

Angular Spectral Reflectance



TPRC

ANGULAR SPECTRAL REFLECTANCE -- GOLD + ZINC

ANGULAR SPECTRAL REFLECTANCE -- GOLD + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error, % | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|-------------------|------------------------------|---|
| ○ | 61-24 | 298 | 0.385-0.76 | | β - AuZn; 2000 Å film. | Vacuum evaporated on glass; 45 degree illumination and 45 degree viewing; data extracted from smooth curve. |

TPRC

PROPERTIES OF HAFNIUM + ZIRCONIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|------------------------------|--------------------|---------------------|
| ○ 0.72 Zr | 13.001 ± 0.005 | 811.6 ± 0.3 |
| □ 0.72 Zr; density corrected | 13.09 ± 0.01 | 817.2 ± 0.6 |
| ◇ 2 Zr | 12.62 | 788 |
| Melting Point: | K | R |
| △ 0.70 Zr | 2248 ± 25 | 4047 ± 45 |

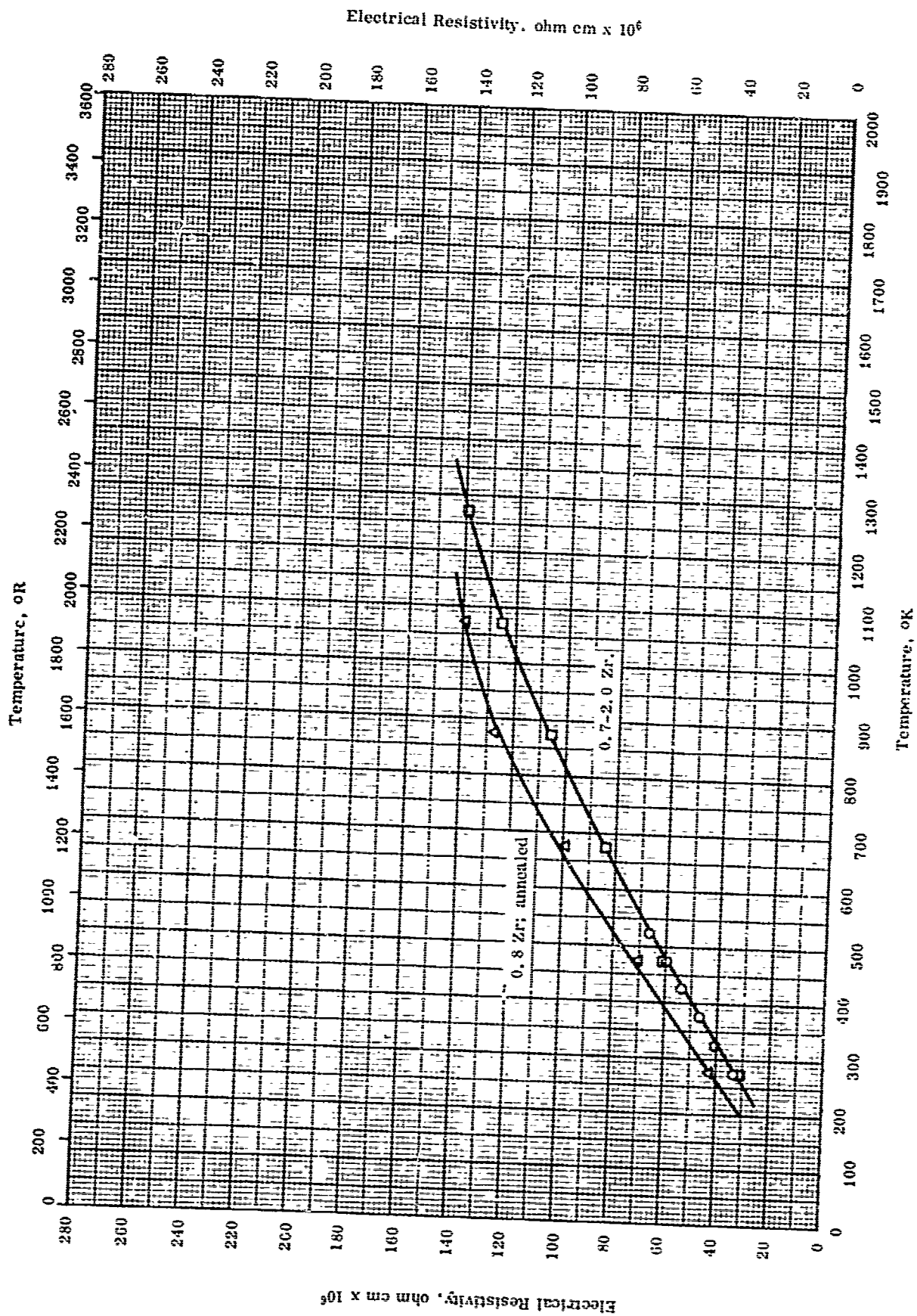
TPRC

PROPERTIES OF HAFNIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 51-10 | 293 | | 0.72 Zr, 0.068 Al, 0.043 O ₂ , 0.008 Si, 0.003 N ₂ , and 0.003 each of Ti and Fe. | Arc-melted, cold swaged (11% reductive), vacuum annealed at 1040 C. |
| □ | 51-10 | 293 | | Same as above. | Same as above except density corrected. |
| △ | 51-10 | 2222-2278 | | 0.70 Zr, 0.018 Al, 0.015 Si, 0.006 Fe, and 0.003 > Ti; iodide crystal bar. | |
| ◇ | 50-15 | 298 | | 2 Zr. | Average of 3 samples. |

TPRC



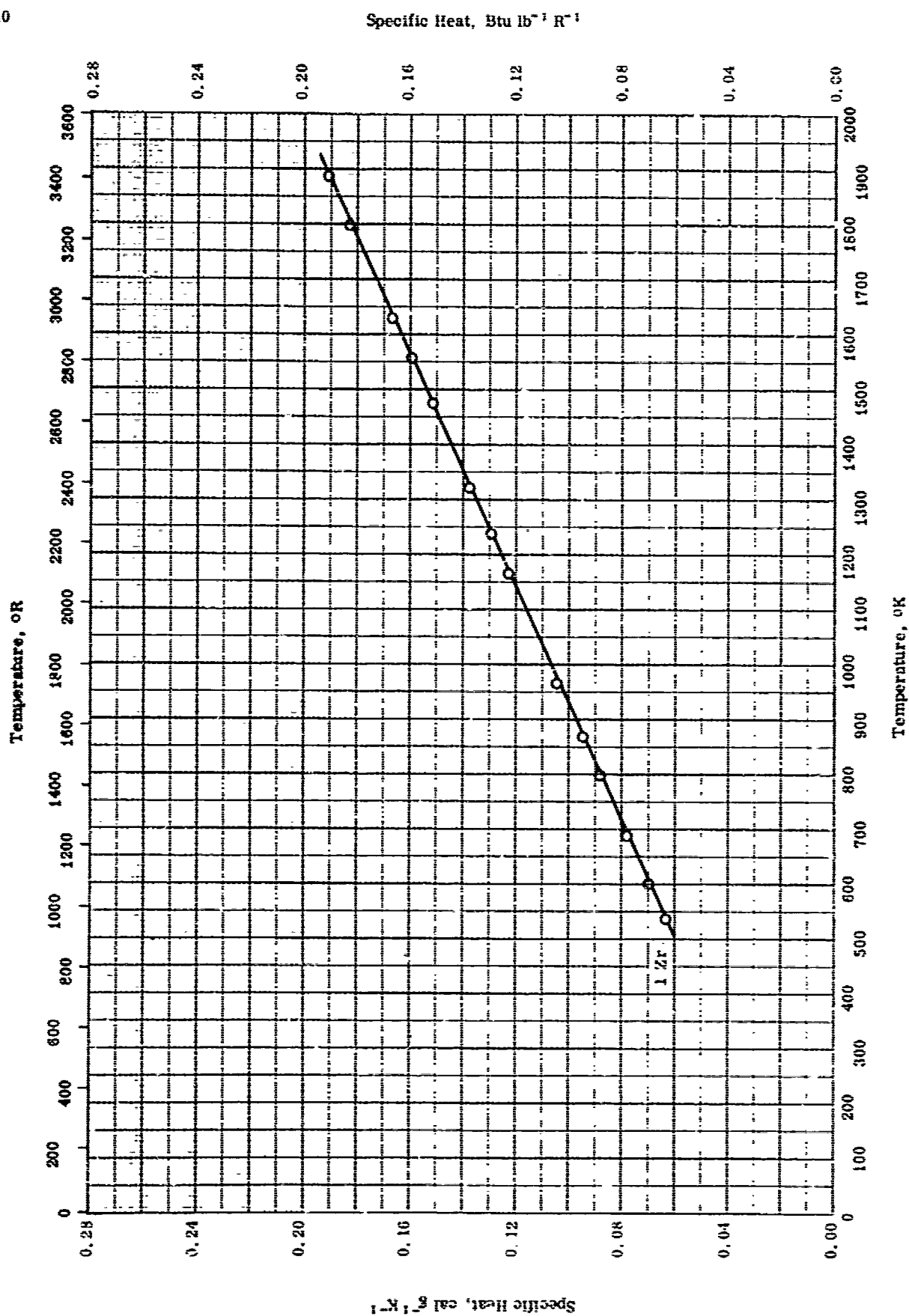
ELECTRICAL RESISTIVITY -- HAFNIUM + ZIRCONIUM

ELECTRICAL RESISTANCE -- HAFNIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ○ | 53-3 | 273-473 | | 2 Zr, and traces of several elements. | As deposited iodide crystal bar. |
| □ | 51-10 | 273-1273 | | 0.70 Zr, 0.018 Al, 0.015 Si, 0.006 Fe, <0.003 Ti, and 0.002 N ₂ . | |
| △ | 51-10 | 273-1073 | | 0.78 Zr, 0.066 Al, 0.037 O ₂ , 0.034 Si, 0.004 N ₂ , and 0.003 > each Ti and Fe. | Are melted, hot rolled, cold rolled, and annealed at 900 C; auth. suspects contamination during processing. |

TPRC



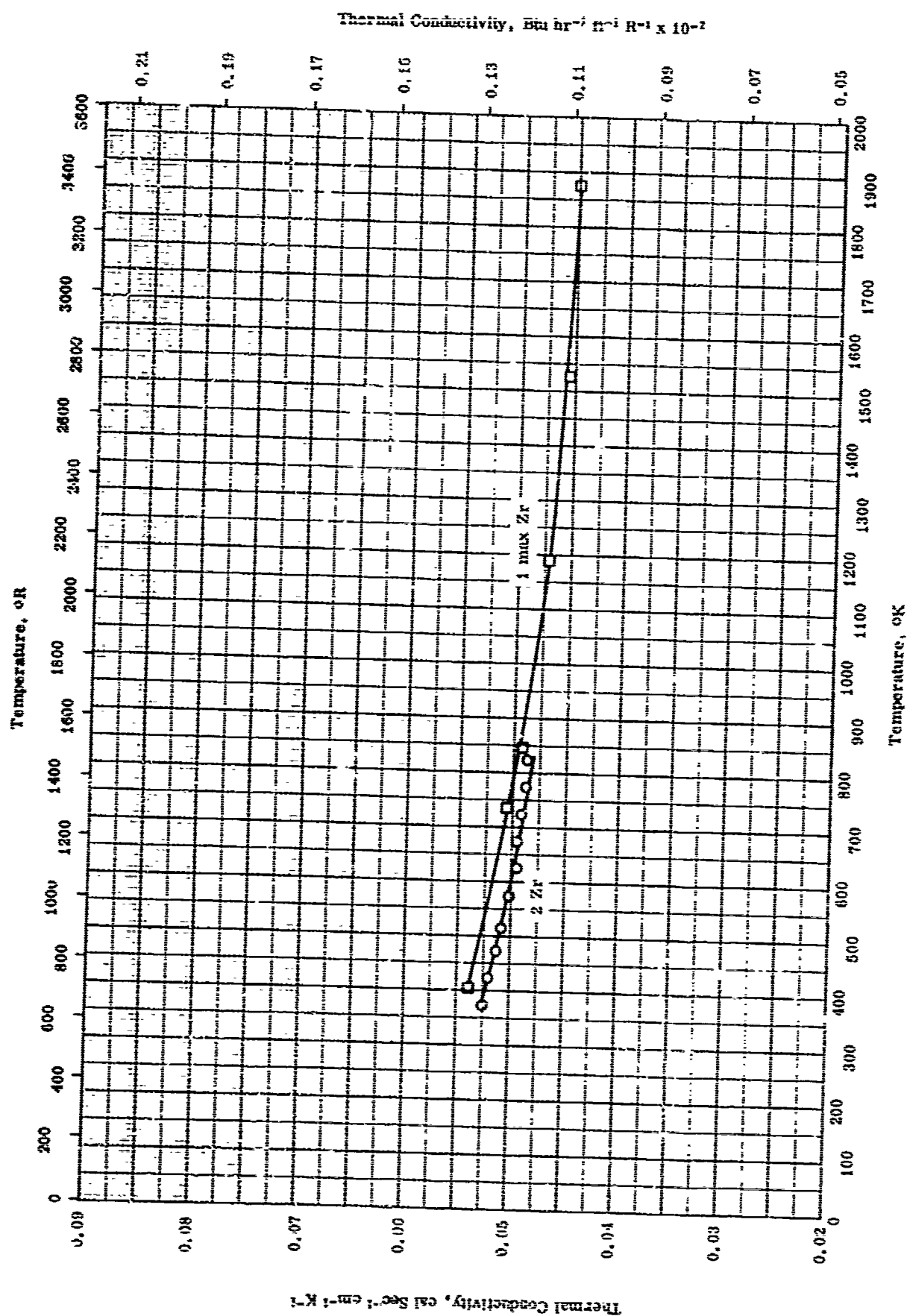
SPECIFIC HEAT -- HAFNIUM + ZIRCONIUM

SPECIFIC HEAT -- HAFNIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|------|--------------------|-------------------|---|---------|
| O | 61-2 | 534-1884 | 3.0 | Crystal bar hafnium; 99.0 Hf, 1 max Zr, 0.1 max (Ti + Si), 0.01 max (Fe + V + Zn), 0.001 max (Cu + Mn + Ni), and 0.0001 max Mg; density 815 lb ft ⁻³ . | |

TPRC



THERMAL CONDUCTIVITY --- HAFNIUM + ZIRCONIUM

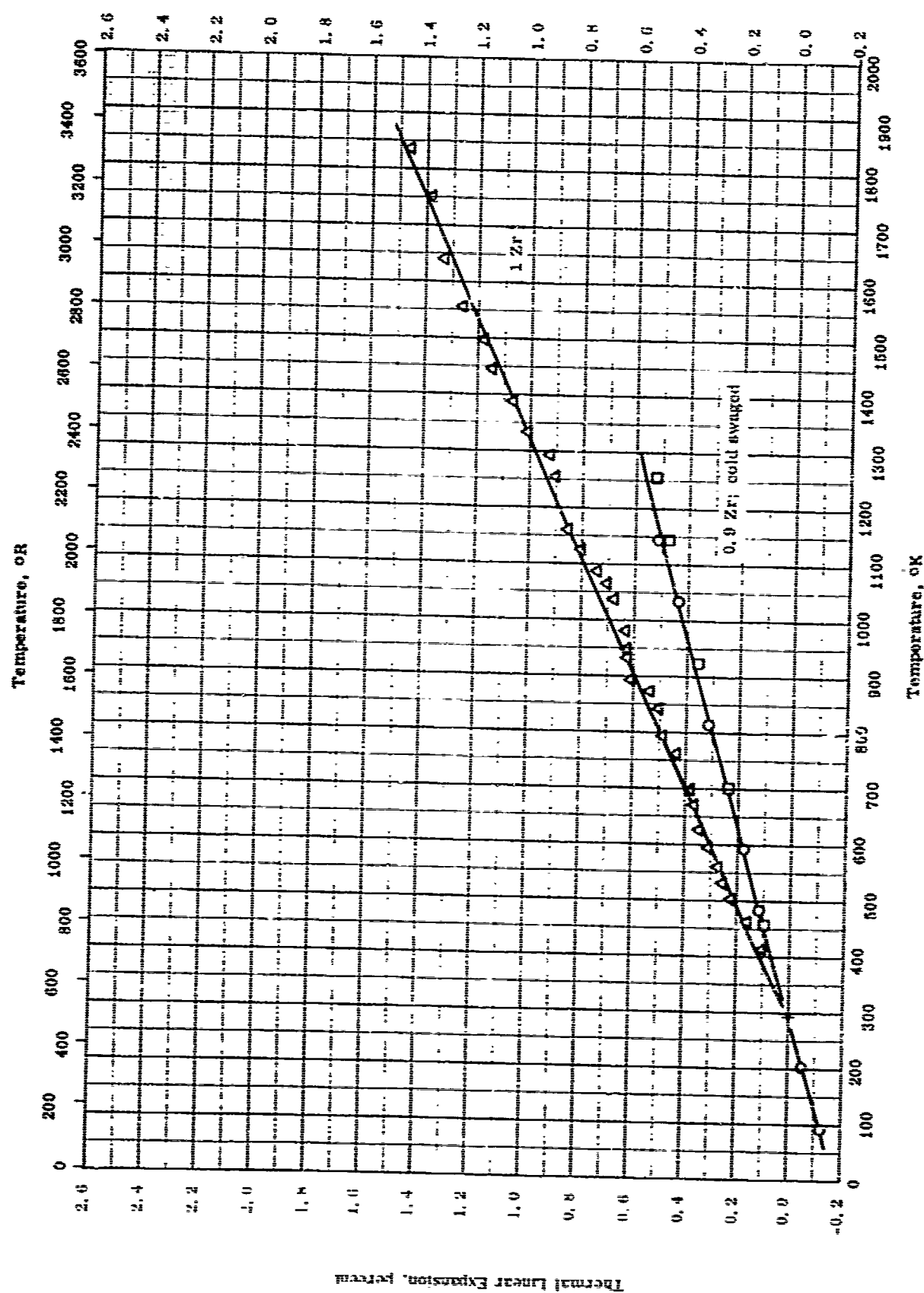
THERMAL CONDUCTIVITY -- HAFNIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| ○ | 01-3 | 273-823 | | 2 Zr, and traces of Pb, Al, W, Fe, Cu, and Zn. | Sample contained 5 one-inch dia disks. |
| □ | 01-2 | 431-1878 | | 1 max Zr, 0.1 max Ti and Si each, 0.01 max V and Zn each, 0.001 max Mn, Ni, and Cu each, and 0.0001 max Mg. | |

TPRC

Thermal Linear Expansion, percent



THERMAL LINEAR EXPANSION --- HAFNIUM + ZIRCONIUM

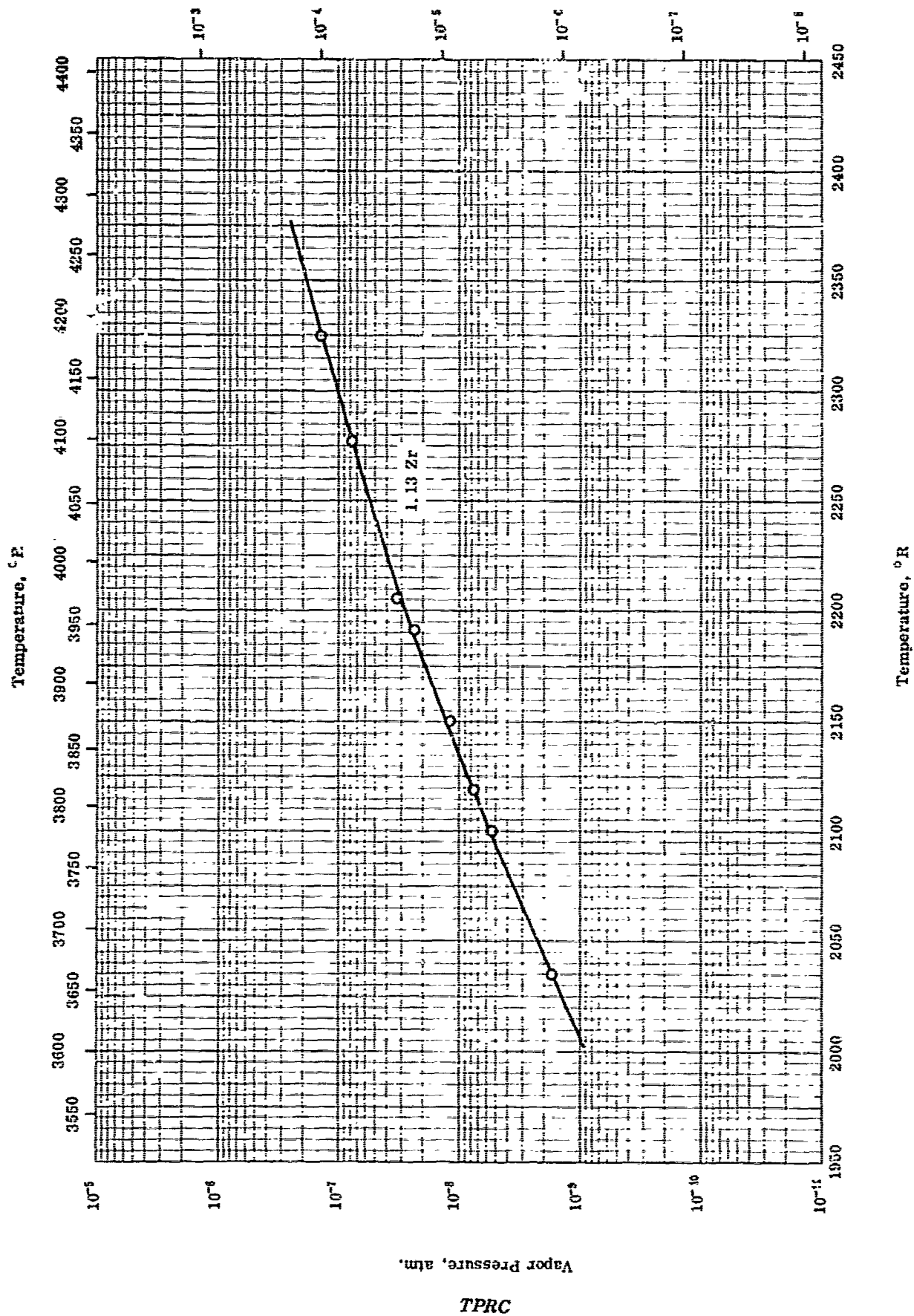
THERMAL LINEAR EXPANSION -- HAFNIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rep. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|---|---|
| O | 51-10 | 91-1140 | | 0.89 Zr, 0.084 Si, 0.074 Al, and 0.003 > Ti, Fe, each. | Cold swaged from iodide crystal bar and annealed at 1000 C. |
| □ | 61-10 | 478-1250 | | 0.89 Zr, 0.047 O ₂ , 0.042 Al, 0.017 Si, and 0.003 > Ti, Fe each. | Same as above; cold swaged 20% after annealing. |
| Δ | 61-2 | 294-1833 | | Crystal bar; 99 hafnium, 1 max Zr, 0.1 max Ti and Si, 0.01 max Fe, V, and Zn, 0.001 max Mn, Ni, and Cu, 0.0001 max Mg; density 13.00 g cm ⁻³ . | |

TPRC

Vapor Pressure, mm Hg

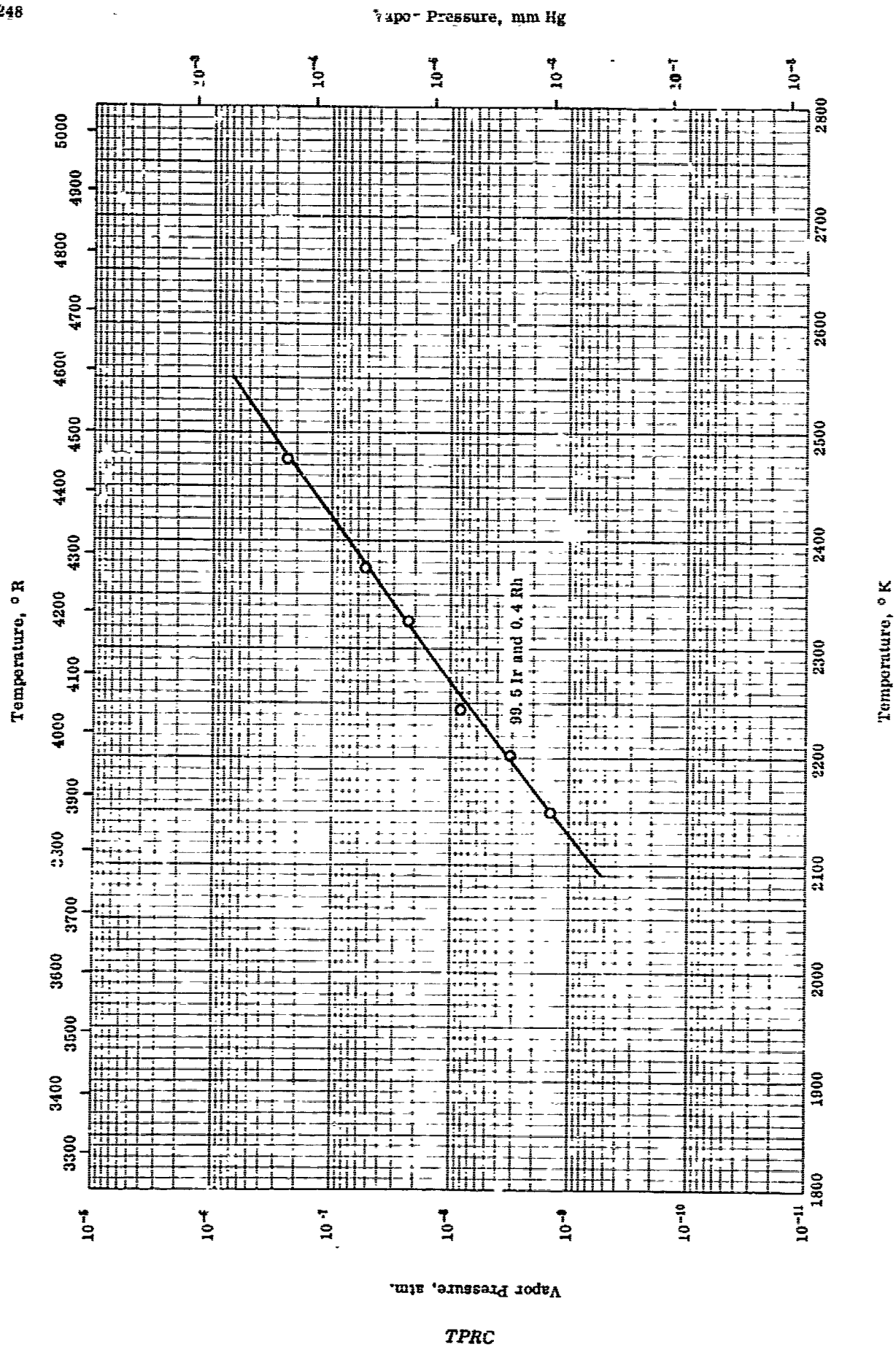


VAPOR PRESSURE -- HAFNIUM + ZIRCONIUM

VAPOUR PRESSURE -- HAFNIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym No | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|------|-------------------|------------------|---|-----------------------|
| O | 64-4 | 2035-2325 | | 1.13 Zr, trace of Fe, Mg and Ti, 0.0081 N, 0.0069 O, and 0.0003 H. | Sample in ring shape. |



VAPOR PRESSURE -- IRIDIUM + RHODIUM

VAPOR PRESSURE -- IRIIDIUM + RHODIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| O | 61-13 | 2140-2477 | | 5b, 5 Ir and 0.4 Rh. | |

TPRC

PROPERTIES OF LANTHANUM + CALCIUM

REPORTED VALUES

Melting Point:

K

R

O 3.0 Ca

1134 \pm 52042 \pm 9

PROPERTIES OF LANTHANUM + CALCIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|----------------------|
| O | 48-5 | 1150-1140 | | 3.0 Ca. | As reduced bisectis. |

TPRC

PROPERTIES OF LANTHANUM + MAGNESIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|------------|--------------------|---------------------|
| O 1.0 > Mg | 5.97 | 373 |

PROPERTIES OF LANTHANUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|--|-----------|
| O | 52-11 | 298 | | 1.0 Mg, 0.025 % Ca, 0.01 % other rare earth, and 0.085 Fe; 50% hexagonal close packed phase and 50% face centered cubic phase. | Extruded. |

PROPERTIES OF LEAD + COPPER

REPORTED VALUES

Density:

| | | |
|---------|-------|-------|
| ○ 20 Cu | 10.76 | 671.0 |
| □ 50 Cu | 10.00 | 624.0 |

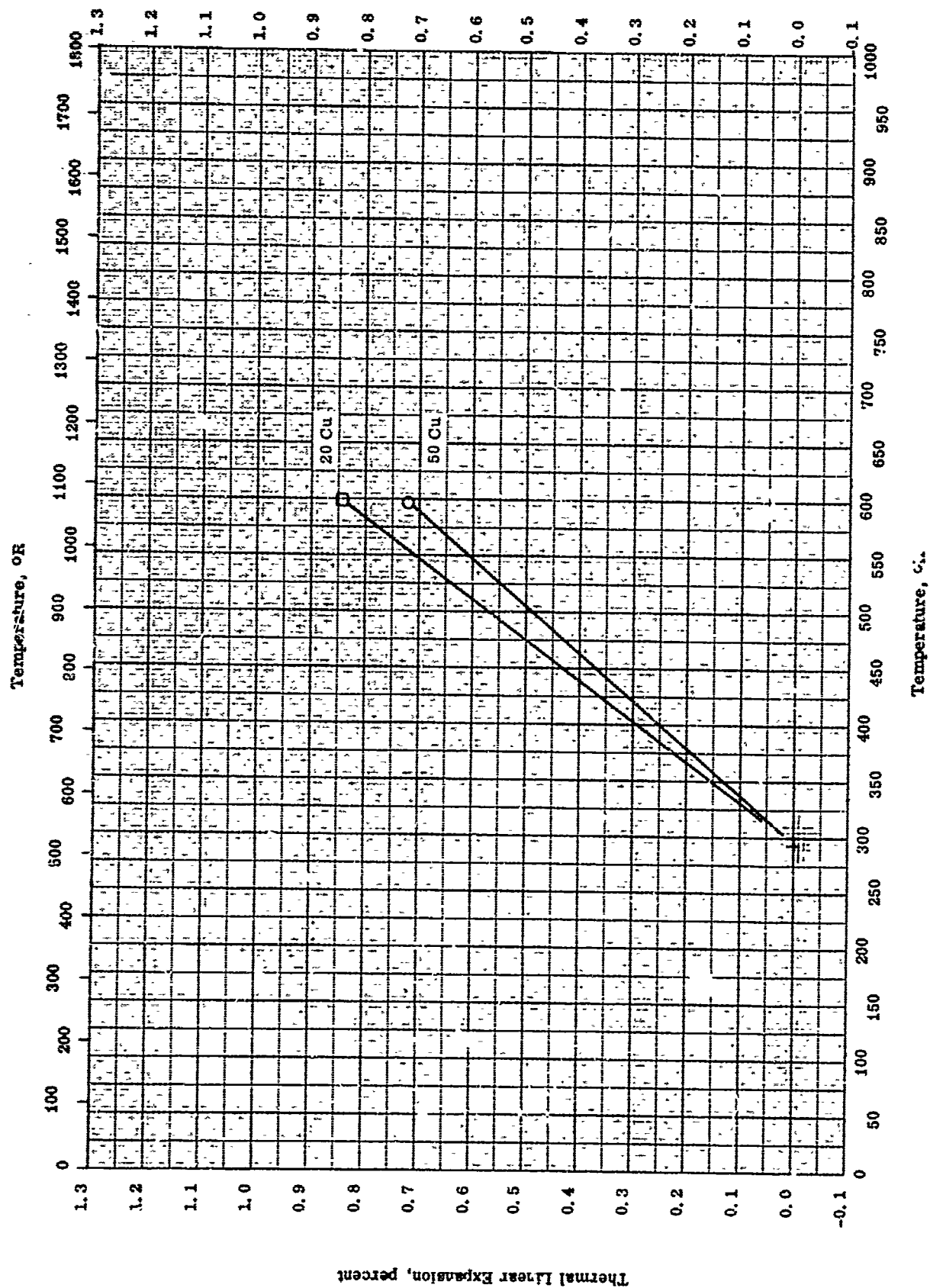
PROPERTIES OF LEAD + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-----------------------|--|
| ○ | 57-40 | 298 | | 20 Cu. | Density from weight in air and in water. Same as above. |
| □ | 57-40 | 298 | | 50 Cu. | |

TPRC

Thermal Linear Expansion, percent



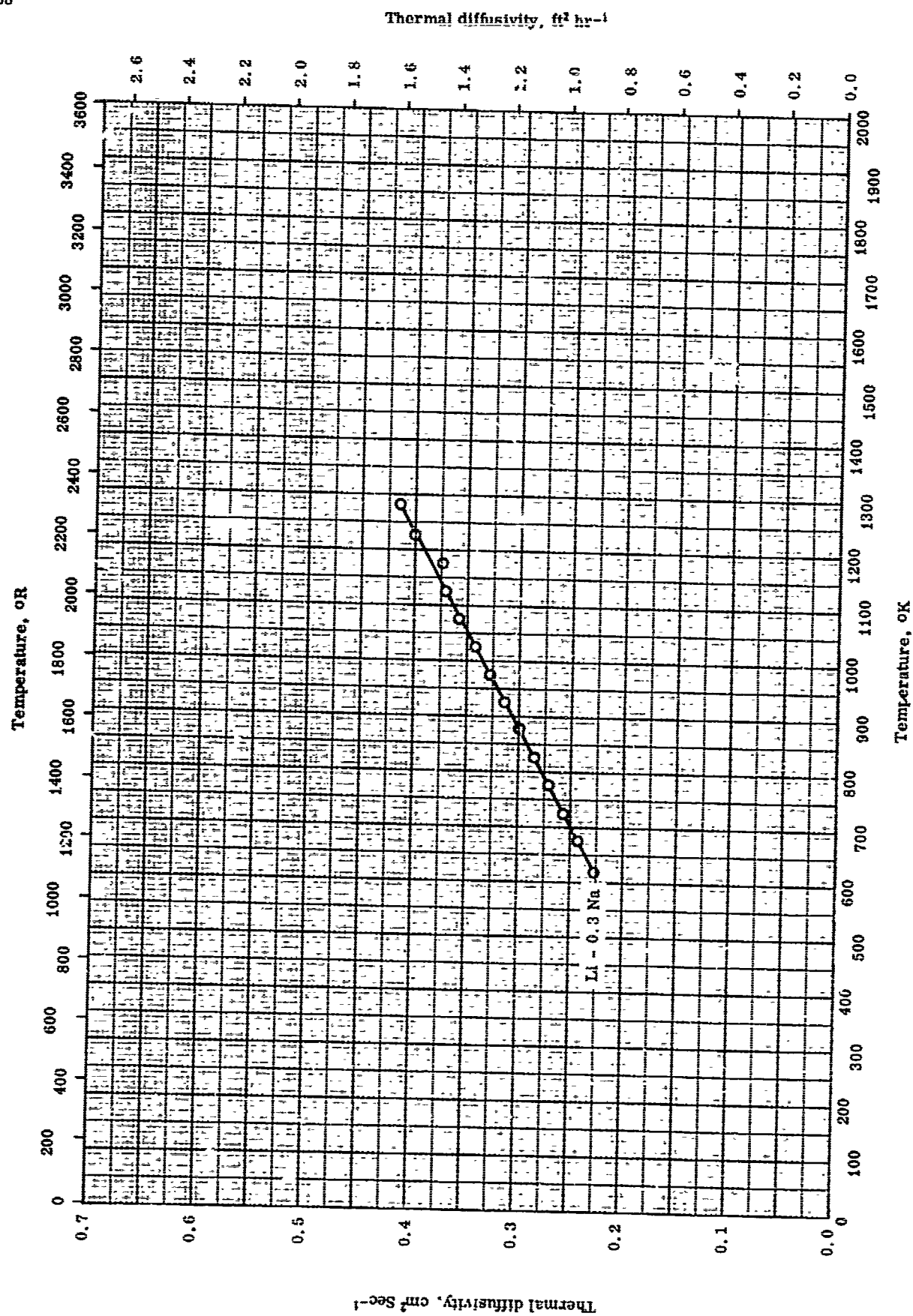
THERMAL LINEAR EXPANSION -- LEAD + COPPER

THERMAL LINEAR EXPANSION -- LEAD + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 57-40 | 293-600 | | 50 Pb and 50 Cu. | $\alpha + \beta - \alpha$ + Liq. at 326 C; $\Delta L/L$ at 326 C = -0.13%. Same as above; $\Delta L/L$ at 326 C not given. |
| □ | 57-40 | 293-600 | | 80 Pb and 20 Cu. | |

TPKc

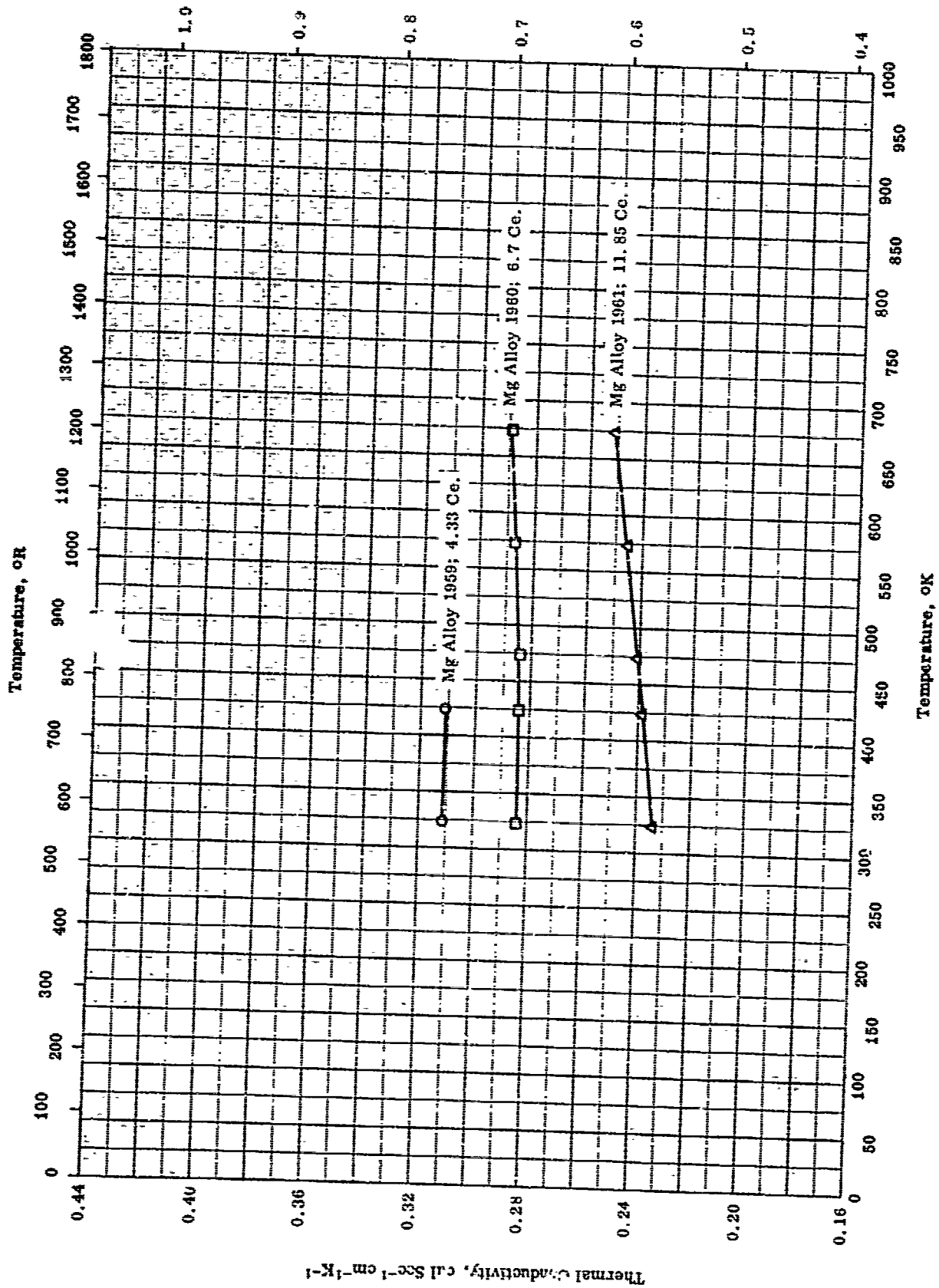


THERMAL DIFFUSIVITY -- LITHIUM + SODIUM

THERMAL DIFFUSIVITY -- LITHIUM + SODIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|--|
| O | 62-1 | 618-1280 | ±2.9 | 98.98>Li, 0.27 Na, 0.19 Fe, 0.18 Mg, 0.08 C, 0.06 Cu, 0.052 Ni, 0.05 Cr, 0.032 Pb, 0.023 Sn, 0.016 Ti, 0.01 Co, 0.01>Sb, 0.01>Zn, 0.006 Ba, 0.0058 Mo, 0.0046 Ca, 0.0044 N, 0.0042 V, 0.0037 Al, 0.003 K, 0.0029 Mn, 0.002 Bi, 0.001 Be, 0.001 Cd, 0.001 In, and 0.0003>Ag. | Filtered through a capillary with an inside dia of 1.5 mm, poured and sealed in a thin-walled steel 1 Kh 189ST tube with 230 mm long, 8.6 mm dia, and 0.2 mm wall thickness in a vacuum of $\sim 1 \times 10^{-2}$ mm Hg; measured in vacuum. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$ 

THERMAL CONDUCTIVITY -- MAGNESIUM + CERIUM

TPRC

THERMAL CONDUCTIVITY -- MAGNESIUM CERUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|-----------|
| O | 64-3 | 323-423 | | Mg Alloy 1959; 4.33 Co in form of mischmetal; Mg contain ≈0.033 Al and ≈0.012 Zn. | Machined. |
| □ | 64-3 | 323-673 | | Mg Alloy 1960; same as above except 6.7 Co. | Machined. |
| Δ | 64-3 | 323-673 | | Mg Alloy 1961; same as above except 11.85 Co. | Machined. |

PROPERTIES OF MAGNESIUM + THORIUM

REPORTED VALUES

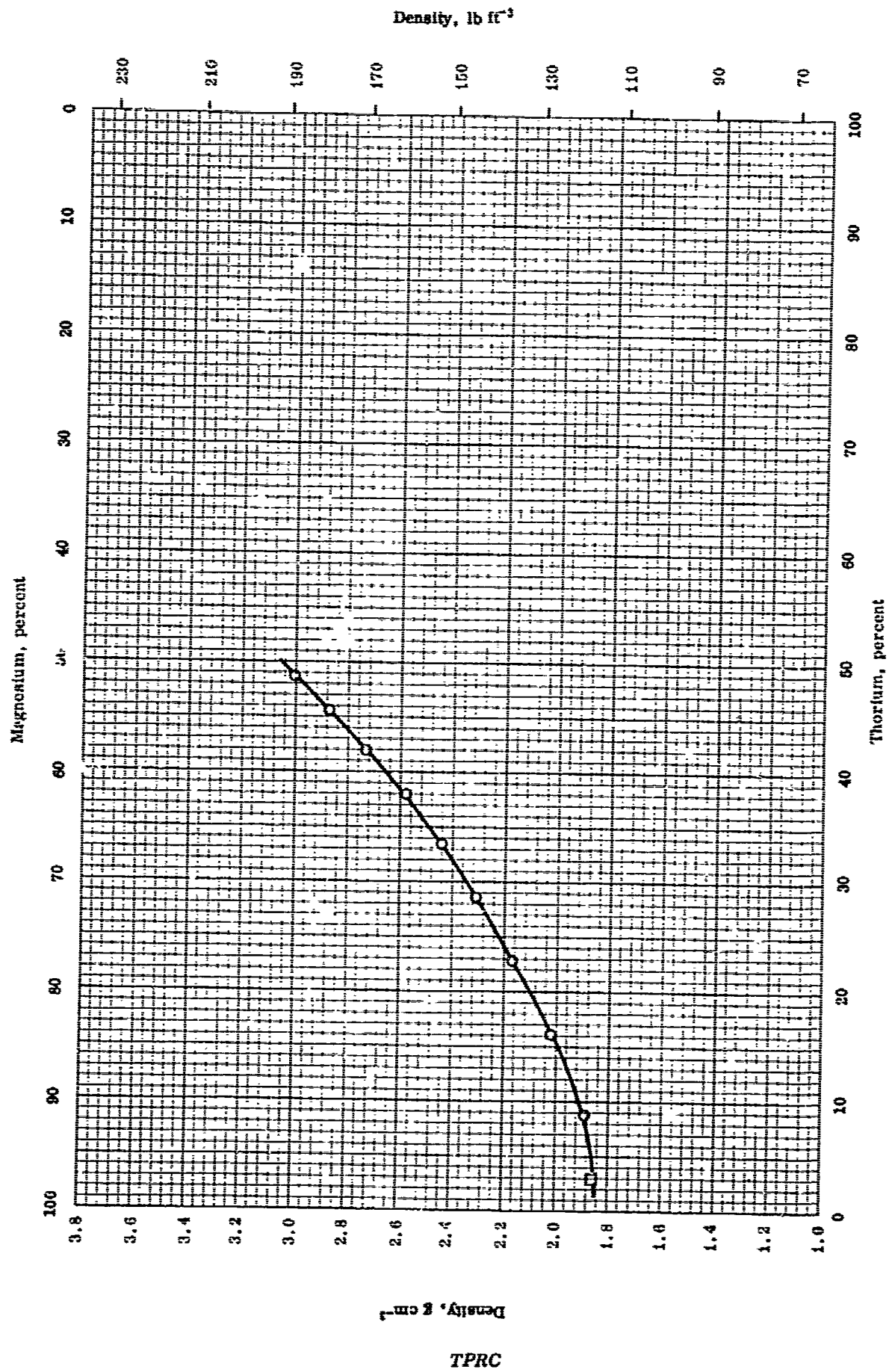
| | | |
|-----------------|---------------------|----------------------|
| Density: | See figure | |
| Melting Point: | K | R |
| Δ HM 31 XA | 878 | 1580 |
| Heat of Fusion: | cal g ⁻¹ | Btu lb ⁻¹ |
| ▲ HM 31 XA | 79 ± 2 | 142 ± 4 |

TPRC

PROPERTIES OF MAGNESIUM + THORIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| Δ | 57-18 | 878 | | Mg Alloy HM 31 XA; 1.93-3.28 Th, 0.05 > Zn, 0.03 > Al, 0.02 > Fe, 0.01 > each Ca, Si, and Sn, 0.005 ± Cu, 0.001 > Ni and 0.001 > pb. Same as above. | |
| ▲ | 57-18 | 878 | | | |



DENSITY -- MAGNESIUM + THORIUM

DENSITY -- MAGNESIUM + THORIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 52-17 | 298 | | 8.8-49 Th. | |
| □ | 52-17 | 298 | | 3 Th. | |

PROPERTIES OF MAGNESIUM + ZINC

REPORTED VALUES

Melting Point:

K

R

O 6.22 Zn

617

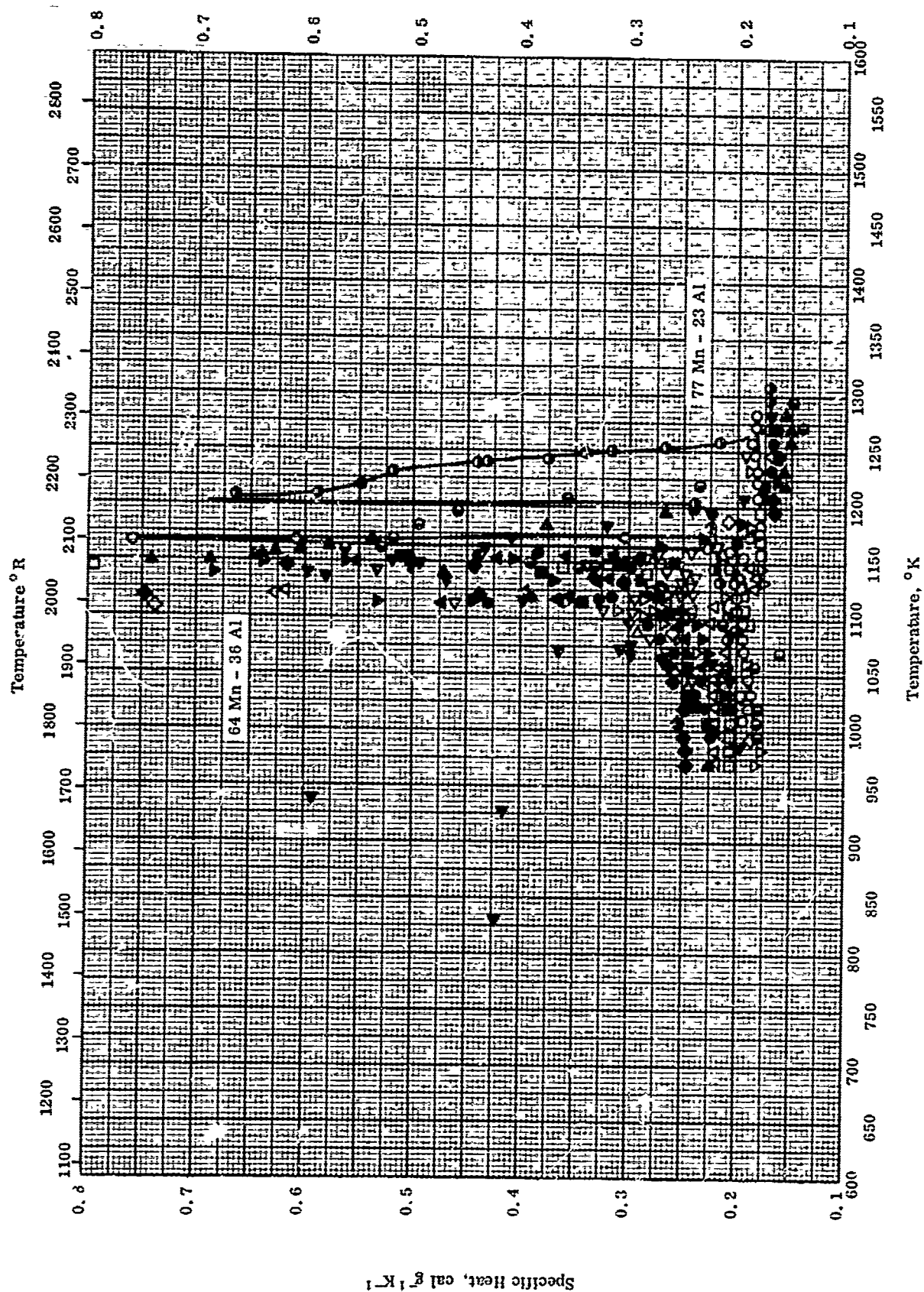
1116

PROPERTIES OF MAGNESIUM + ZINC

REFERENCE INFORMATION

| Sym bol | Rel. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| O | 84-10 | 617 | | 03.78 Mg and 0.23 Zn. | M.P. from metallographic inspection for signs of chilled liquid in sample quenched from various temperature levels. |

TPRC

Specific Heat, $\text{Btu lb}^{-1} \text{R}^{-1}$ 

SPECIFIC HEAT -- MANGANESE + ALUMINUM

TPRC

SPECIFIC HEAT -- MANGANESE + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 58-17 | 970-1273 | | Mn alloy A-47; 64.4 Mn and 35.6 Al; prepared from 99.9 Mn and 99.99 Al. | Melted in an induction furnace, annealed for 1 hr at 950 C; slowly cooled to 700 C; annealed again at 950 C for 5 hrs then slowly cooled to room temperature in a vacuum. |
| □ | 58-17 | 970-1273 | | Mn alloy A-48; 65.3 Mn and 34.7 Al; same raw materials as above. | Same as above. |
| △ | 58-17 | 970-1273 | | Mn alloy A-49; 66.30 Mn and 33.70 Al; same raw materials as above. | Same as above. |
| ◇ | 58-17 | 993-1188 | | Mn alloy A-49.5; same as above. | Same as above. |
| ▽ | 58-17 | 970-1273 | | Mn alloy A-50; 67.1 Mn and 32.9 Al; same raw materials as above. | Same as above. |
| ▷ | 58-17 | 1040-1189 | | A-50.5; same as above. | Same as above. |
| ◁ | 58-17 | 970-1273 | | Mn alloy A-51; 69.0 Mn and 31.00 Al; same raw materials as above. | Same as above. |
| ● | 58-17 | 970-1273 | | Mn alloy A-52; 68.8 Mn and 31.2 Al; same raw materials as above. | Same as above. |
| ■ | 58-17 | 970-1273 | | Mn alloy A-53; 70.4 Mn and 29.6 Al; same raw materials as above. | Same as above. |
| ▲ | 58-17 | 970-1273 | | Mn alloy A-54; 71.4 Mn and 28.6 Al; same raw materials as above. | Same as above. |

(Continued onto next page)

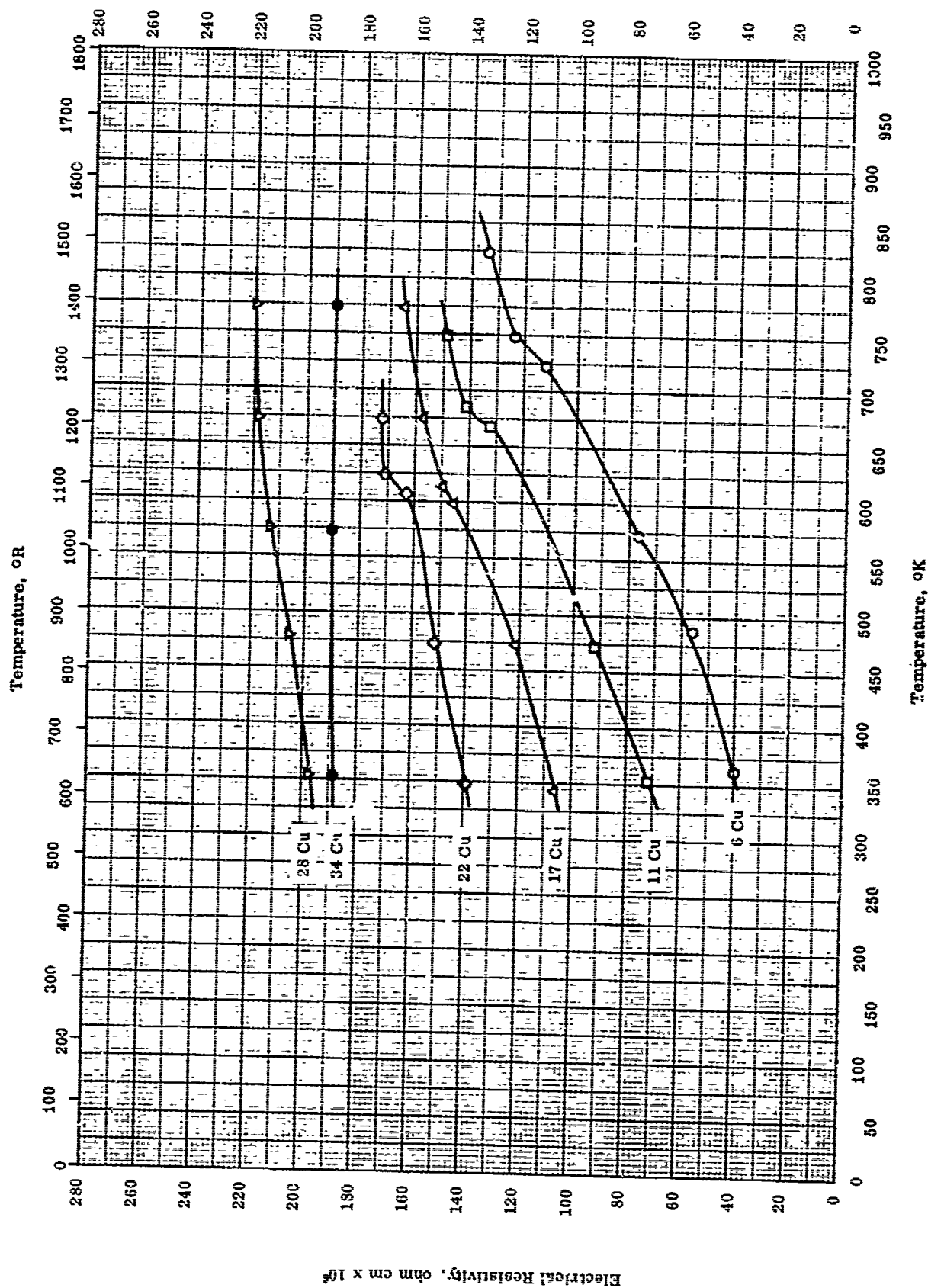
SPECIFIC HEAT -- MANGANESE + ALUMINUM (continued)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|----------------|
| ◆ | 58-17 | 970-1273 | | Mn alloy A-55; 71.8 Mn and 28.2 Al; same raw materials as above. | Same as above. |
| ▼ | 58-17 | 970-1273 | | Mn alloy A-56; 73.2 Mn and 26.5 Al; same raw materials as above. | Same as above. |
| ▲ | 58-17 | 970-1273 | | Mn alloy A-57; 73.4 Mn and 26.6 Al; same raw materials as above. | Same as above. |
| ◄ | 58-17 | 970-1273 | | Mn alloy A-58; 73.7 Mn and 26.3 Al; same raw materials as above. | Same as above. |
| ◉ | 58-17 | 970-1273 | | Mn alloy A-59; 77.0 Mn and 23.0 Al; same raw materials as above. | Same as above. |
| ○ | 58-17 | 970-1273 | | Mn alloy A-60; 77.3 Mn and 22.7 Al; same raw materials as above. | Same as above. |

Electrical Resistivity, ohm cm x 10⁶

271



ELECTRICAL RESISTIVITY -- MANGANESE + COPPER

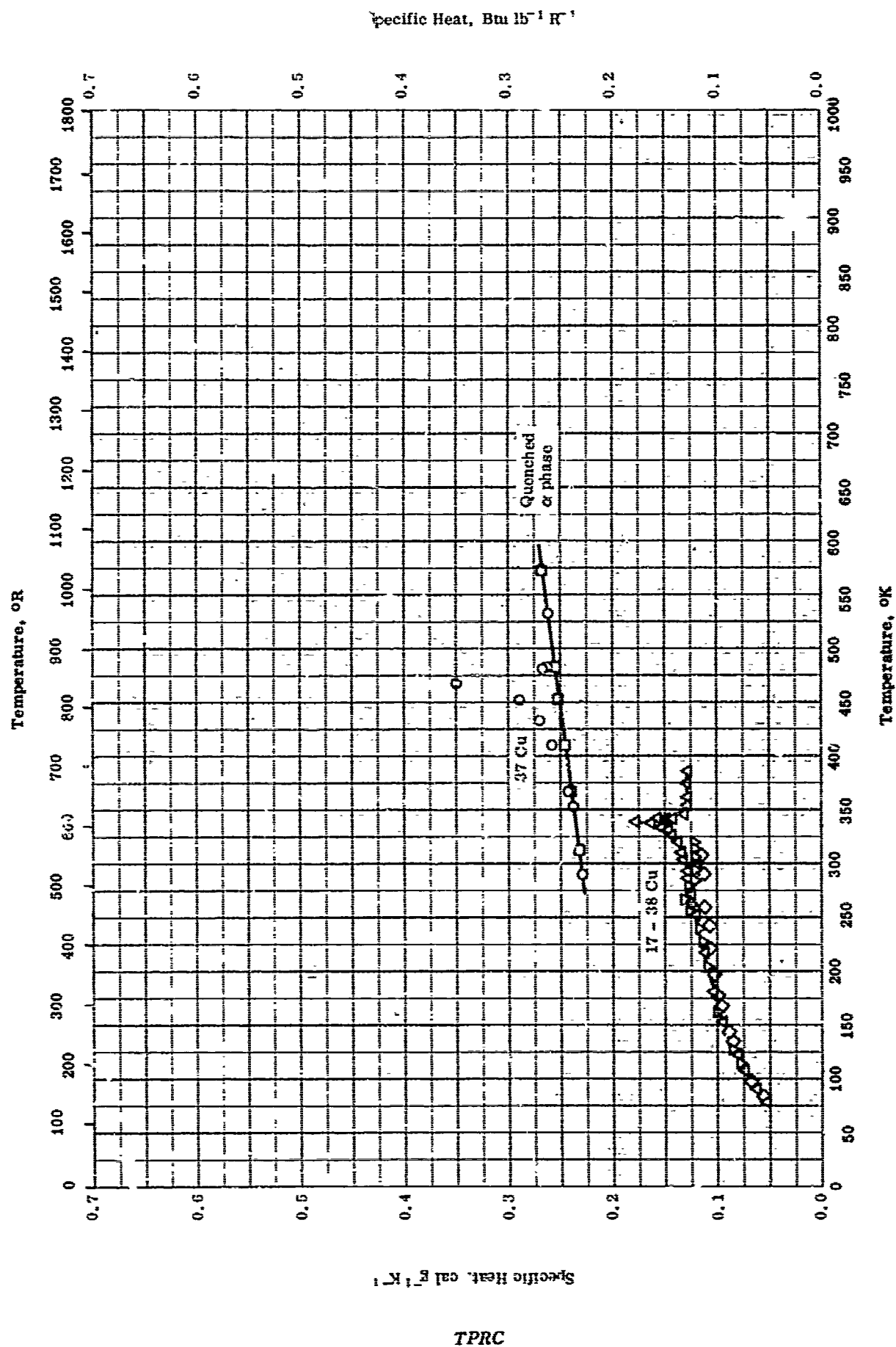
TPRC

ELECTRICAL RESISTIVITY -- MANGANESE + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|------------------------|---------|
| ○ | 57-29 | 363-823 | | 94.26 Mn and 5.74 Cu. | |
| □ | 57-29 | 353-748 | | 88.61 Mn and 11.39 Cu. | |
| △ | 57-29 | 343-773 | | 83.05 Mn and 16.95 Cu. | |
| ◇ | 57-29 | 348-673 | | 77.57 Mn and 22.43 Cu. | |
| ▽ | 57-29 | 353-773 | | 72.17 Mn and 27.83 Cu. | |
| ● | 57-29 | 353-773 | | 65.8 Mn and 34.20 Cu. | |

TPRC

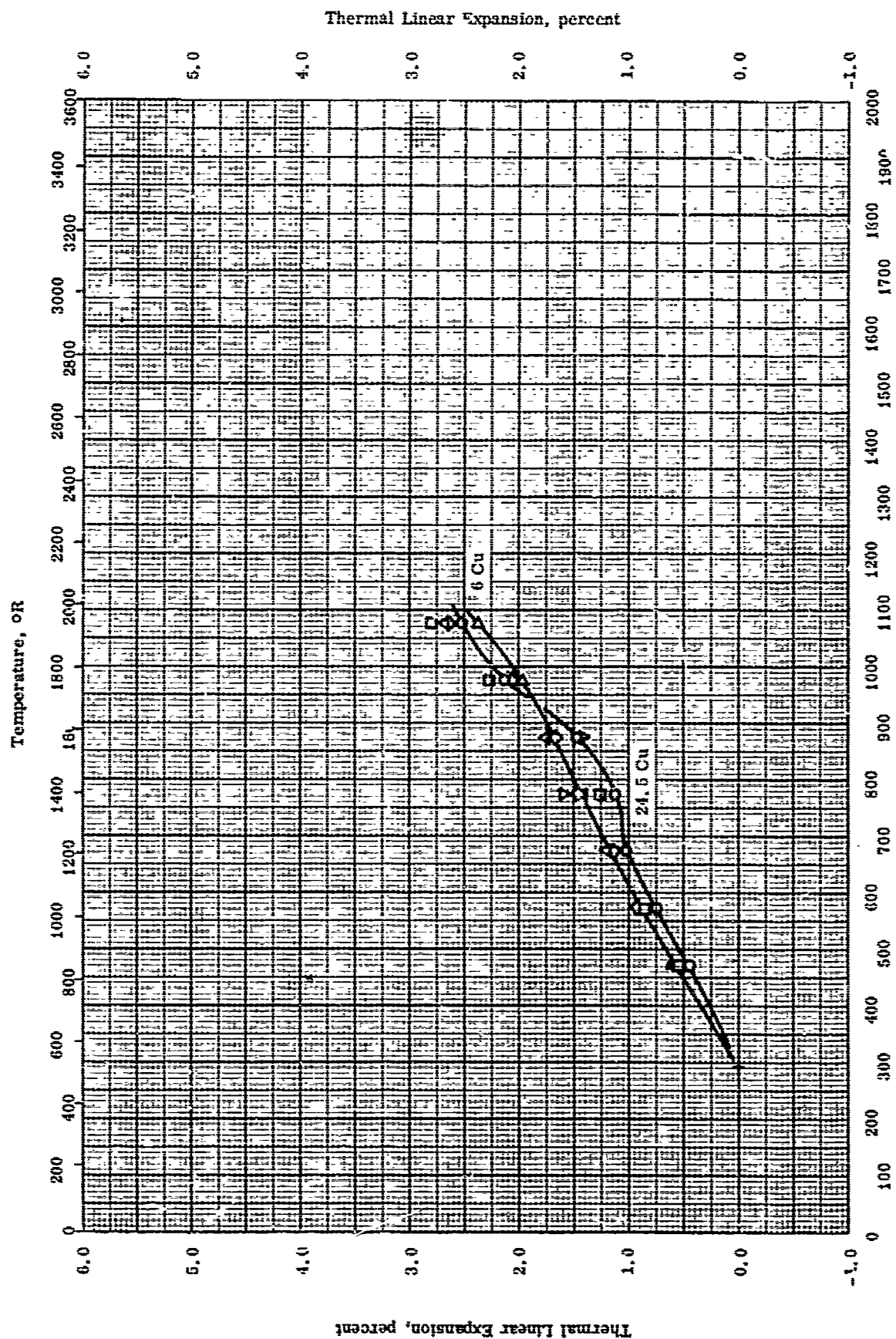


SPECIFIC HEAT -- MANGANESE + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. r--r % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|---|---|
| ○ | 58-18 | 290-573 | | 63.1 Mn and 36.9 Cu. | Cooled from 1932 R at 36 R hr ⁻¹ . |
| □ | 58-18 | 290-573 | | Same as above; face centered cubic α -phase; metastable. | Same values for 2 samples: (a) quenched from 1932 R in water at 531 R, (b) held 300 hrs at 1482 R and cooled to room temperature at 4 R hr ⁻¹ . |
| △ | 61-14 | 79-386 | | 83.0 Mn and 17.0 Cu. | Prepared by melting Analar grade manganese and copper in argon arc furnace. |
| ◇ | 61-14 | 79-307 | | 61.6 Mn and 38.4 Cu. | Same as above. |
| ▽ | 61-14 | 79-320 | | 77.5 Mn and 22.6 Cu. | Same as above. |

TPRC

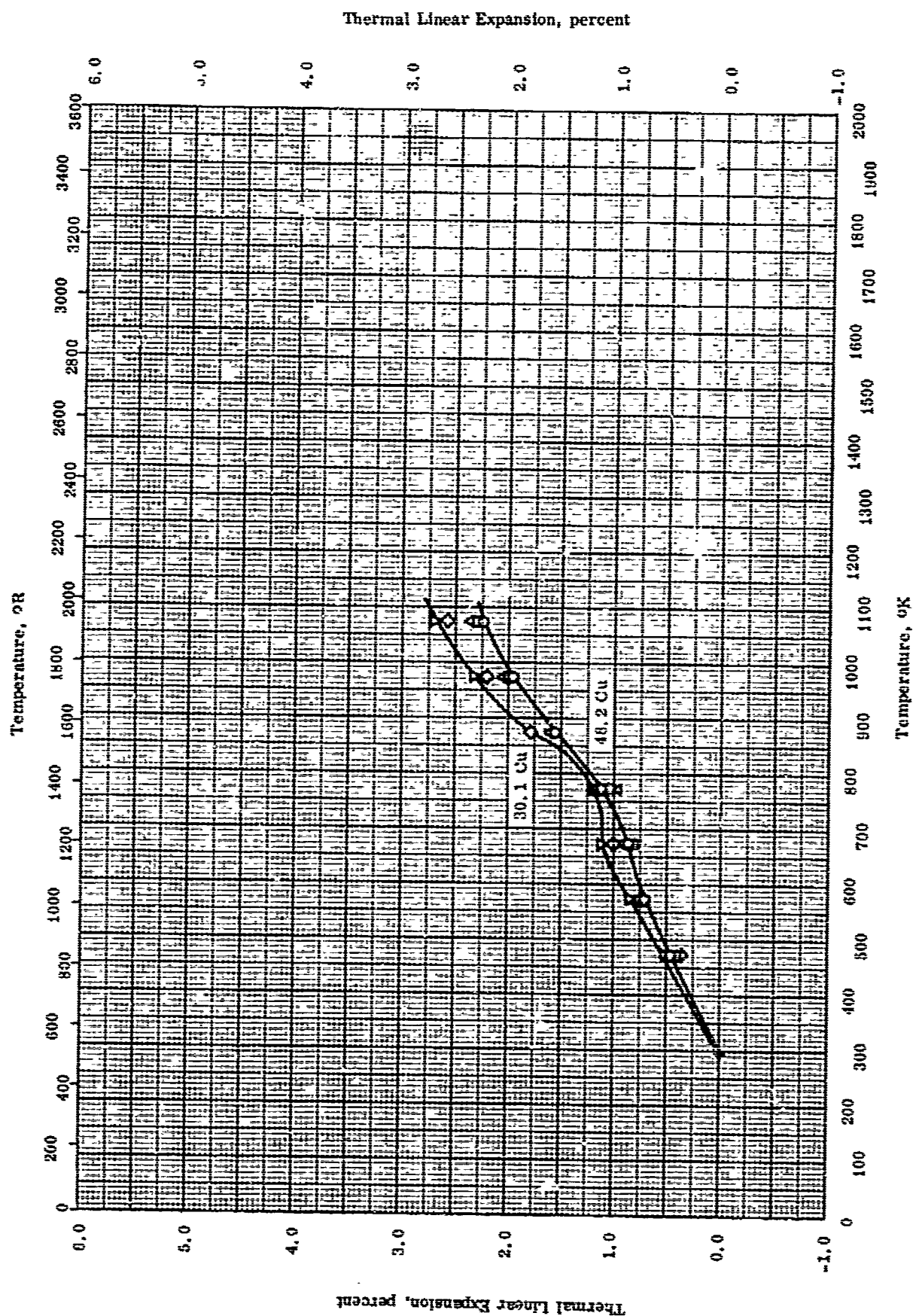


THERMAL LINEAR EXPANSION -- MANGANESE + COPPER
(5 < Cu < 25)

THERMAL LINEAR EXPANSION -- MANGANESE + COPPER
(5 < Cu < 25)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|------------------------|
| ○ | 55-38 | 473-1073 | | 75.5 Mn and 24.5 Cu; prepared from electrolytic materials. | Quenched and annealed. |
| □ | 55-38 | 473-1073 | | 79.4 Mn and 20.1 Cu; same as above. | Same as above. |
| △ | 55-38 | 473-1073 | | 83.7 Mn and 15.0 Cu; same as above. | Same as above. |
| ◇ | 55-38 | 473-1073 | | 88.5 Mn and 10.5 Cu; same as above. | Same as above. |
| ▽ | 55-38 | 473-1073 | | 93.0 Mn and 5.6 Cu; same as above. | Same as above. |
| △ | 55-38 | 473-1073 | | 94.0 Mn and 6.0 Cu; same as above. | Same as above. |

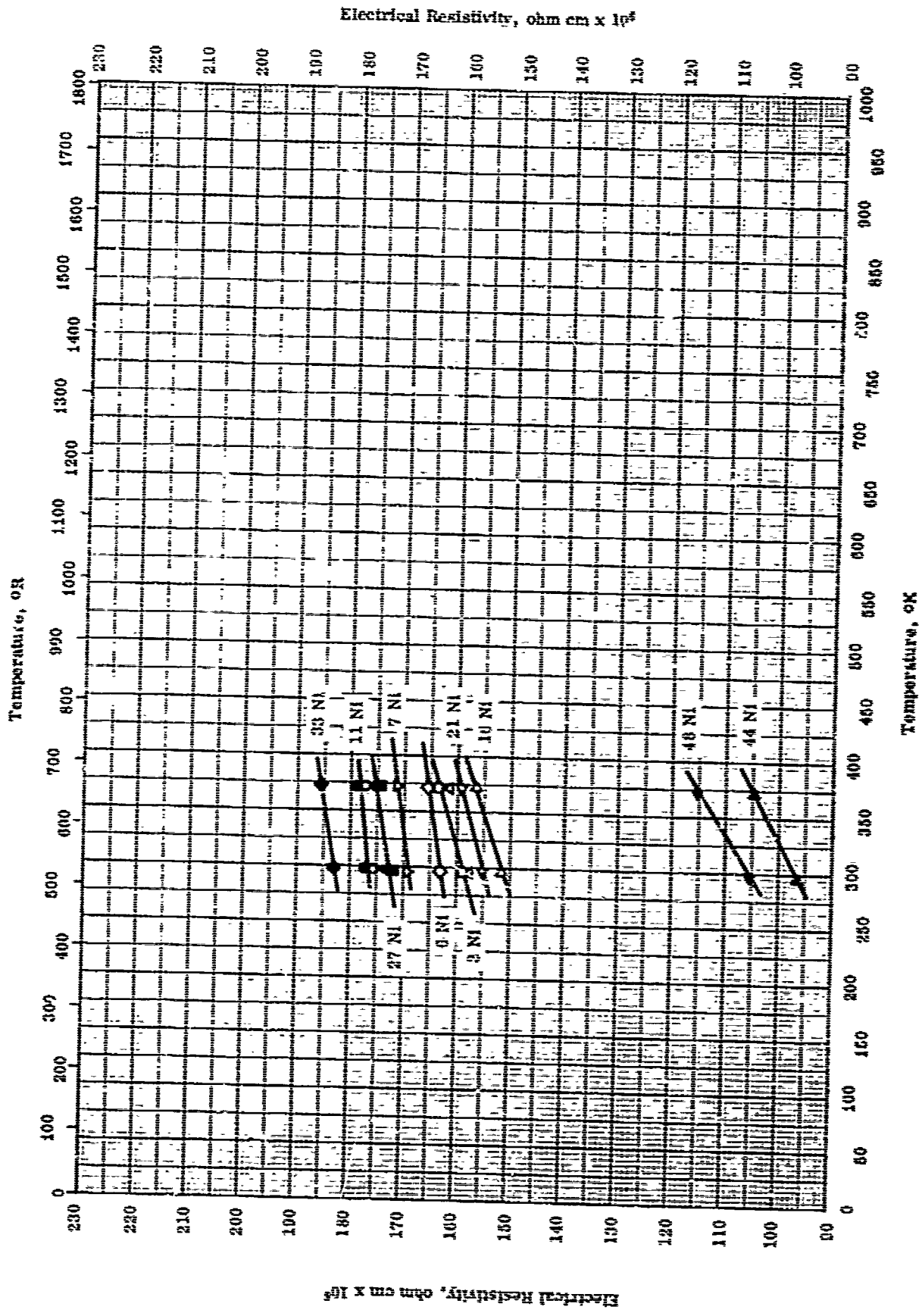


THERMAL LINEAR EXPANSION -- MANGANESE + COPPER
(30 < Cu < 50)

THERMAL LINEAR EXPANSION -- MANGANESE + COPPER
(30 < Cu < 50)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|------------------------|
| ○ | 55-38 | 473-1073 | | 51.6 Mn, and 45.2 Cu; prepared from electrolytic pure materials. | Quenched and annealed. |
| □ | 55-38 | 473-1073 | | 53.4 Mn, 45.7 Cu; same as above. | Same as above. |
| △ | 55-38 | 473-1073 | | 58.6 Mn, 41.4 Cu; same as above. | Same as above. |
| ◇ | 55-38 | 473-1073 | | 65.0 Mn, 35 Cu; same as above. | Same as above. |
| ▽ | 55-38 | 473-1073 | | 69.0 Mn, 30.1 Cu; same as above. | Same as above. |



ELECTRICAL RESISTIVITY -- MANGANESE + NICKEL

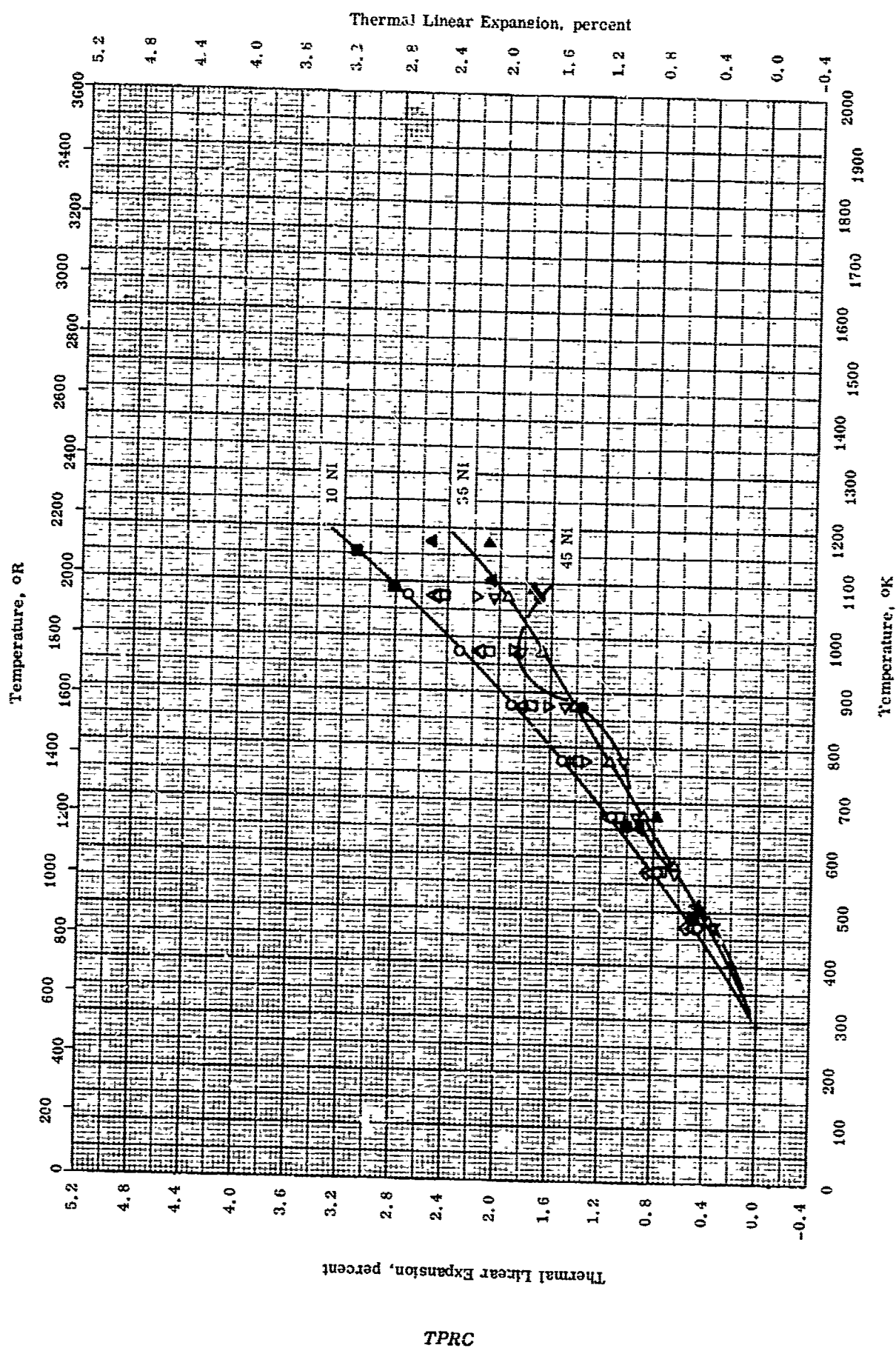
TPRC

ELECTRICAL RESISTIVITY -- MANGANESE + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---|
| □ | 49-6 | 298-373 | | 3.23 NI. | Annealed in steps from 980 C to 500 C; the entire process lasting 5 days. |
| △ | 49-6 | 298-373 | | 3.51 NI. | Same as above. |
| ◇ | 49-6 | 298-373 | | 6.04 NI. | Same as above. |
| ▽ | 49-6 | 298-373 | | 7.74 NI. | Same as above. |
| ○ | 49-6 | 298-373 | | 10.79 NI. | Same as above. |
| ● | 49-6 | 298-373 | | 11.75 NI. | Same as above. |
| △ | 49-6 | 298-373 | | 15.75 NI. | Same as above. |
| ▽ | 49-6 | 298-373 | | 20.68 NI. | Same as above. |
| ■ | 49-6 | 298-373 | | 26.32 NI. | Same as above. |
| ▲ | 49-6 | 298-373 | | 26.98 NI. | Same as above. |
| ◆ | 49-6 | 298-373 | | 32.69 NI. | Same as above. |
| ▲ | 49-6 | 298-373 | | 43.99 NI. | Same as above. |
| ▼ | 49-6 | 298-373 | | 47.60 NI. | Same as above. |

TPRC



THERMAL LINEAR EXPANSION -- MANGANESE + NICKEL

THERMAL LINEAR EXPANSION -- MANGANESE + NICKEL

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rpt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|---|--|
| ○ | 55-38 | 293-1073 | | 89.7 Mn and 10.3 Ni; prepared from electrolytic purify raw materials. | Quenched and homogenized. |
| □ | 55-38 | 293-1073 | | 84.0 Mn, and 16.0 Ni; same as above. | Same as above. |
| △ | 55-38 | 293-1073 | | 79.8 Mn, and 20.2 Ni; same as above. | Same as above. |
| ◇ | 55-38 | 293-1073 | | 75.1 Mn, and 24.9 Ni; same as above. | Same as above. |
| ▽ | 55-38 | 293-1073 | | 70.1 Mn, and 29.9 Ni; same as above. | Same as above. |
| △ | 55-38 | 293-1073 | | 65.4 Mn, and 34.6 Ni; same as above. | Same as above. |
| ▽ | 55-38 | 293-1073 | | 59.3 Mn, and 40.7 Ni; same as above. | Same as above. |
| ● | 55-38 | 293-1073 | | 54.8 Mn, and 45.2 Ni; same as above. | Same as above. |
| ■ | 49-6 | 473-1173 | | 89.21 Mn, and 10.79 Ni; same as above. | Prepared in alumina crucibles in an induction furnace. |
| ▲ | 49-6 | 473-1173 | | 67.31 Mn, and 32.69 Ni; same as above. | Same as above. |
| ▲ | 49-6 | 473-1173 | | 57.05 Mn, and 42.95 Ni; same as above. | Same as above. |

PROPERTIES OF MANGANESE + TITANIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| ○ 35.1 Ti | 5.31 | 394 |
| □ 48.3 Ti | 5.96 | 372 |

TPRC

PROPERTIES OF MANGANESE + TITANIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 54-20 | 298 | | 35.1 Ti. | Density from weight in air and in water. |
| □ | 54-20 | 298 | | 48.3 Ti | Same as above. |

TPRC

PROPERTIES OF MOLYBDENUM + IRON

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| O 0.25 Fe | 10.22 | 638 |

TPRC

PROPERTIES OF MOLYBDENUM + IRON

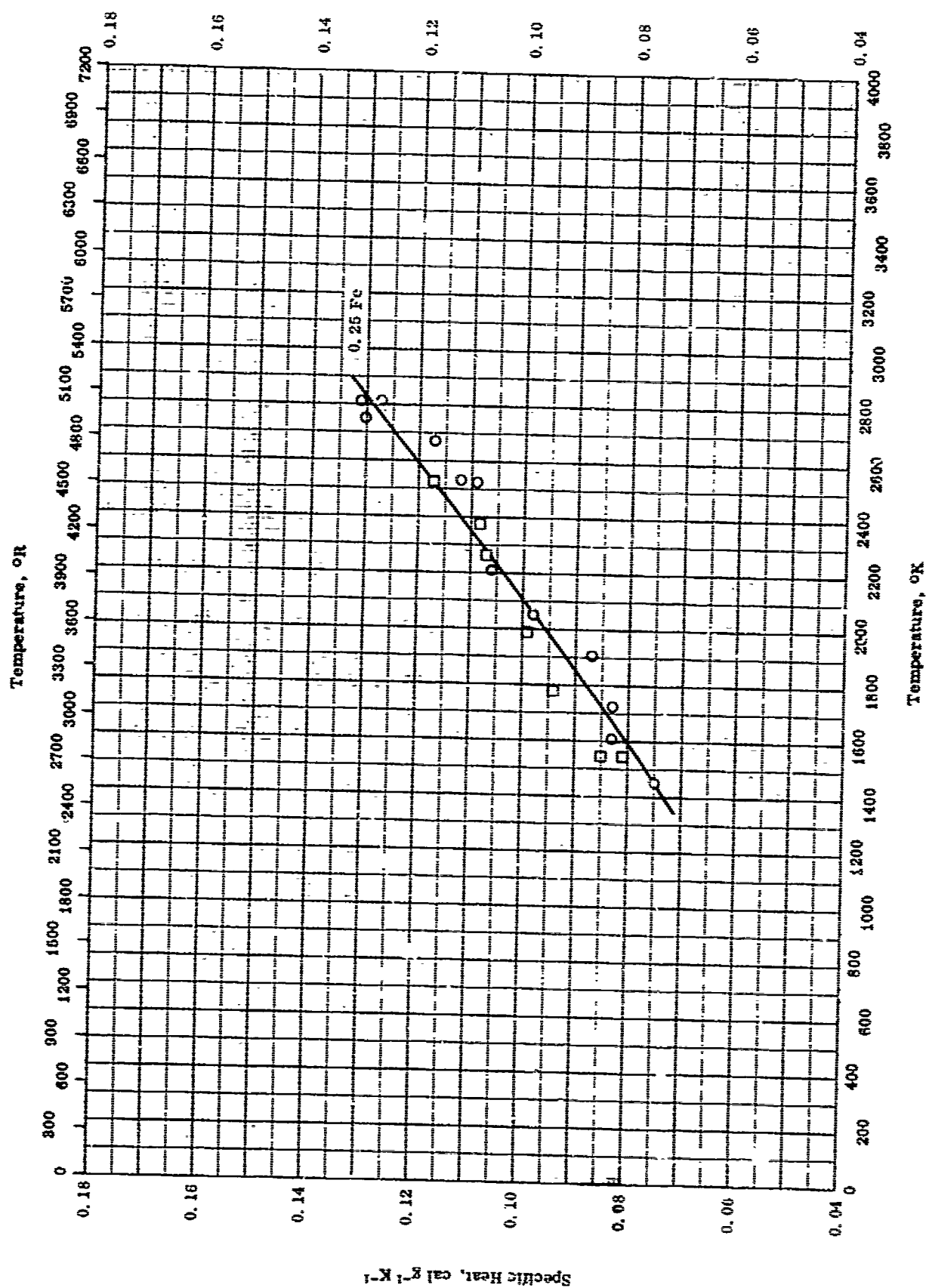
REFERENCE INFORMATION

| Sym. bol | Ref. | Temp. Range, °K | Repl. Error, % | Sample Specifications | Remarks |
|-------------|------|--------------------|-------------------|---|---------|
| ○ | 50-7 | 298 | | 0.25 Fe, 0.073 Si, 0.021 Ti, 0.013 Cu, 0.007 C, and 0.003 Cr. | |

TPRC

Specific Heat, Btu lb⁻¹ R⁻¹

257



SPECIFIC HEAT -- MOLYBDENUM + IRON

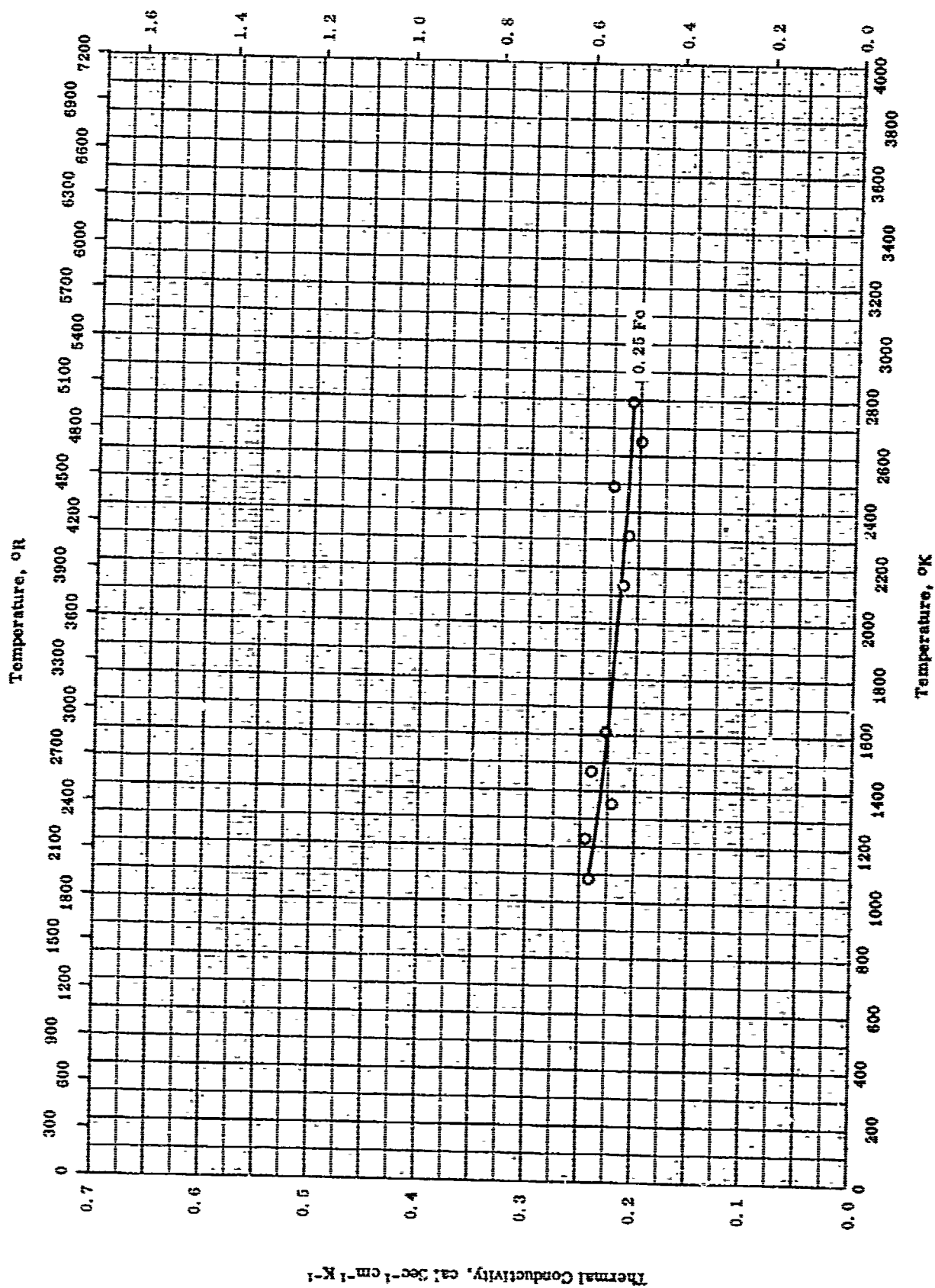
SPECIFIC HEAT -- MOLYBDENUM + IRON

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|-------------------------|
| ○ | 56-7 | 1456-2811 | | Before test: 0.25 Fe, 0.073 Si, 0.021 Ti, 0.013 Cu, 0.007 C, 0.003 Cr; and after test: 0.063 Si, 0.008 C, others unchanged; density 638 lb ft ⁻³ . | Are melted; heating. |
| □ | 55-7 | 1456-2811 | | Same as above. | Same as above; cooling. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

259



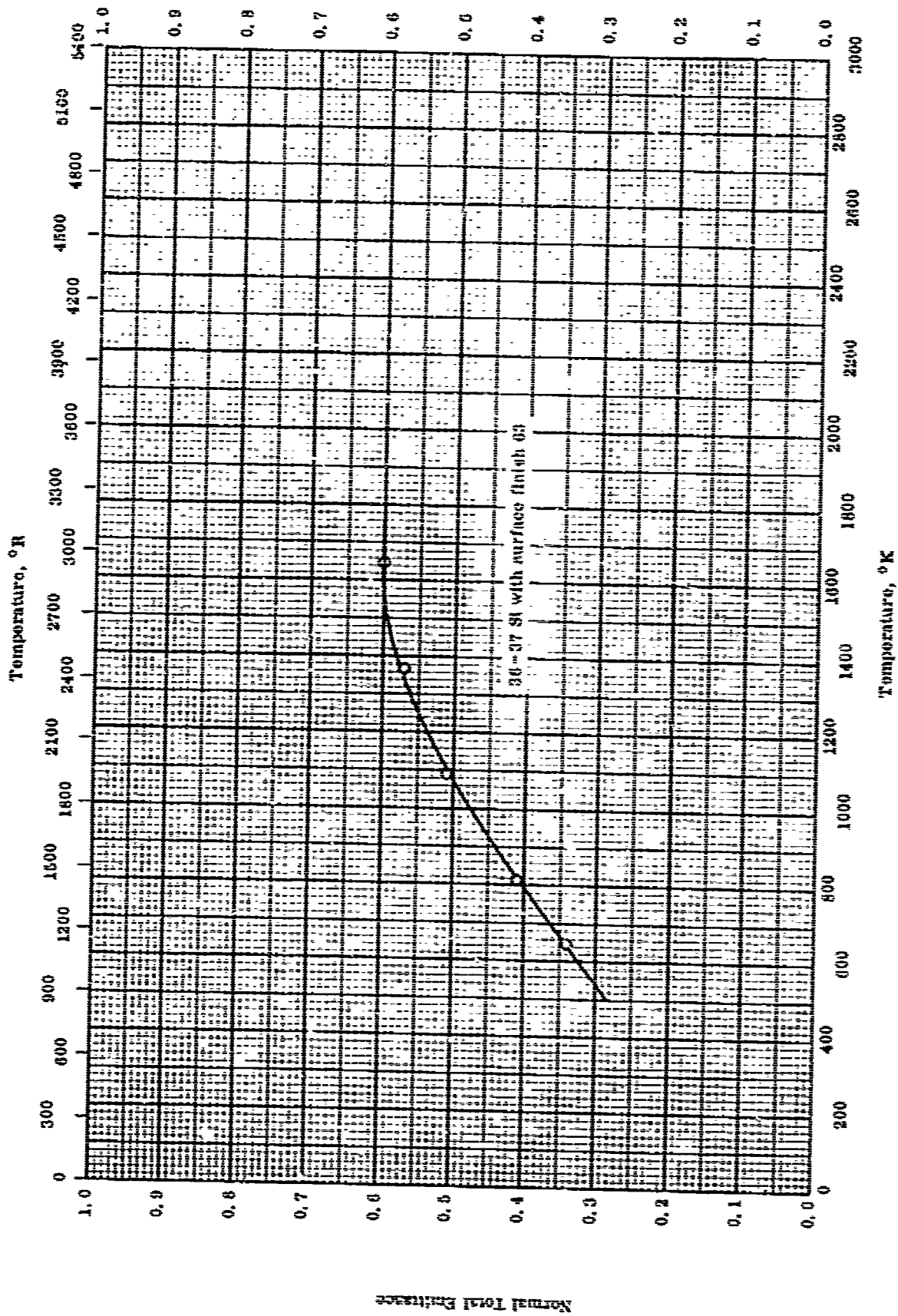
THERMAL CONDUCTIVITY -- MOLYBDENUM + IRON

THERMAL CONDUCTIVITY -- MOLYBDENUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---------|
| O | 50-7 | 1083-2747 | | Before test composition: 0.25 Fe, 0.073 Si, 0.021 Ti, 0.013 Cu, 0.007 C, 0.0003 Cr; after test composition: 0.563 Si, 0.008 C, and others unchanged; density 638 lb ft ⁻³ | |

TPRC



NORMAL TOTAL EMITTANCE --- MOLYBDENUM + SILICON

NORMAL TOTAL EMITTANCE -- MOLYBDENUM + SILICON

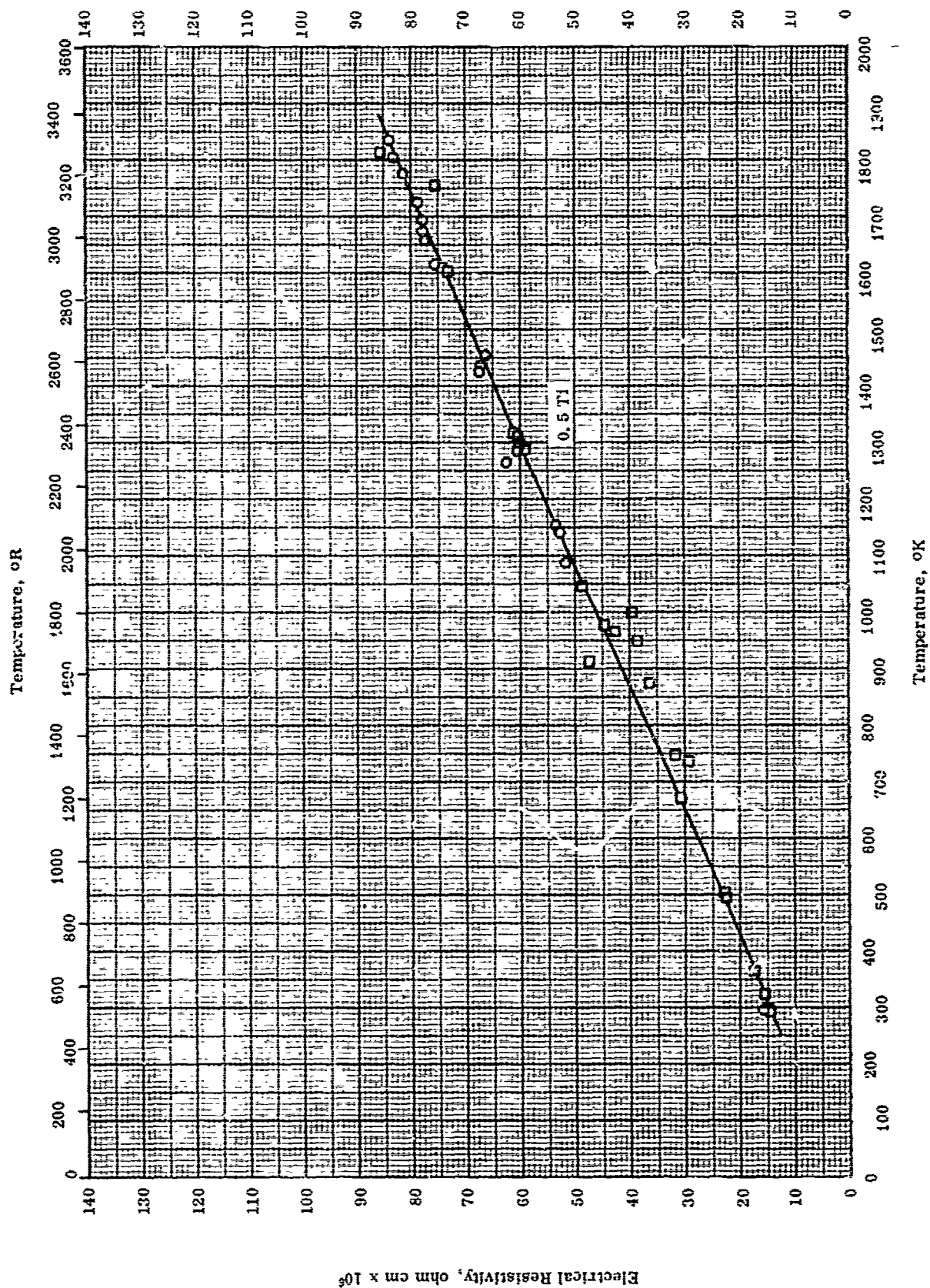
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--------------------------------------|
| O | 67-18 | 644-1644 | ± 20 | 62-64.5 Mo and 36-37 Si; block; surface finish 63. | Measured in moisture removed helium. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$

293



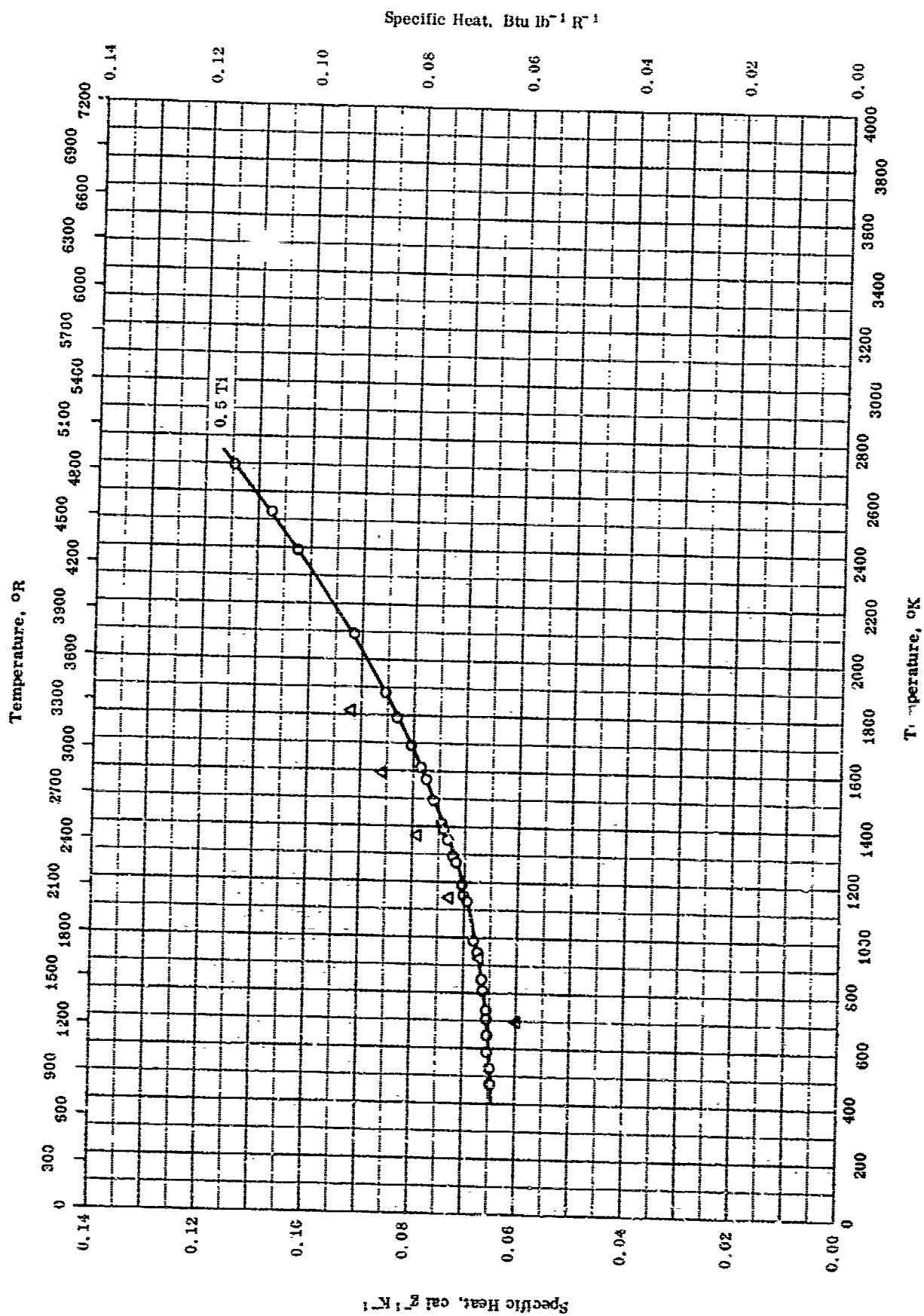
ELECTRICAL RESISTIVITY -- MOLYBDENUM + TITANIUM

ELECTRICAL RESISTIVITY -- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---|
| ○ | 62-4 | 297-1833 | 2.4 | 98.6 Mo and 0.5 Ti. | Hot pressed; maximum exposure temp. 4430 F. |
| □ | 62-4 | 297-1811 | 2.4 | Same as above. | Same as above. |

TPRC



SPECIFIC HEAT -- MOLYBDENUM + TITANIUM

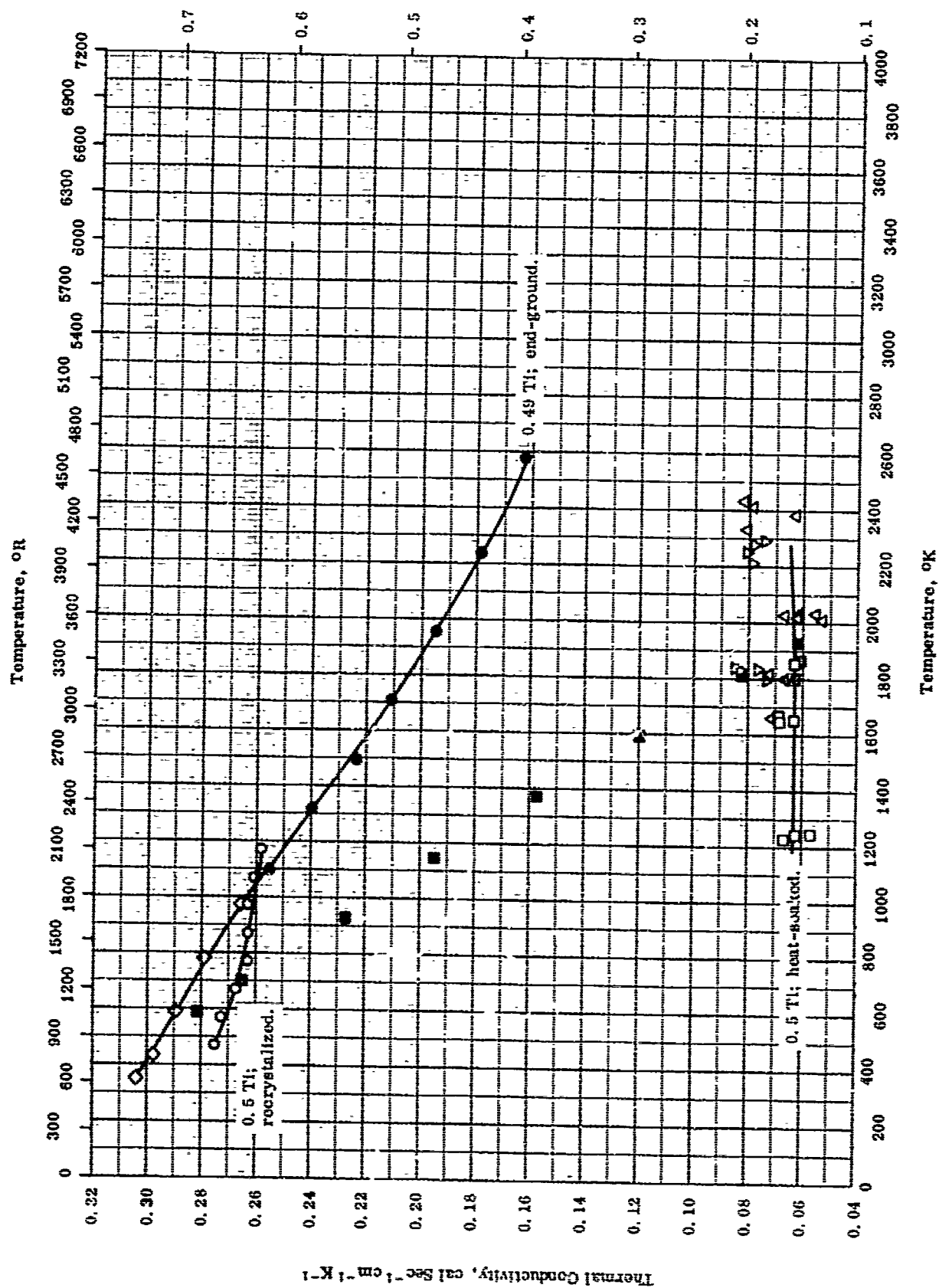
SPECIFIC HEAT -- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-----------------------|-------------------|------------------|---|--------------------------|
| O | 63-1 | 475-2700 | ±5.0 | Mo-0.5 Ti-0.08 Zr alloy; 0.5 Ti, 0.07 Zr, 0.029 C, 0.005 >Si, 0.002 >Fe, 0.001 >Ni, 0.0005 O ₂ , 0.0003 N ₂ , and 0.0001 H ₂ ; density 622 lb ft ⁻³ . | |
| Δ | 60-11 also 61-6 | 700-1810 | 0.7-2.9 | 0.5 Titanium alloy of molybdenum. | Under helium atmosphere. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

297



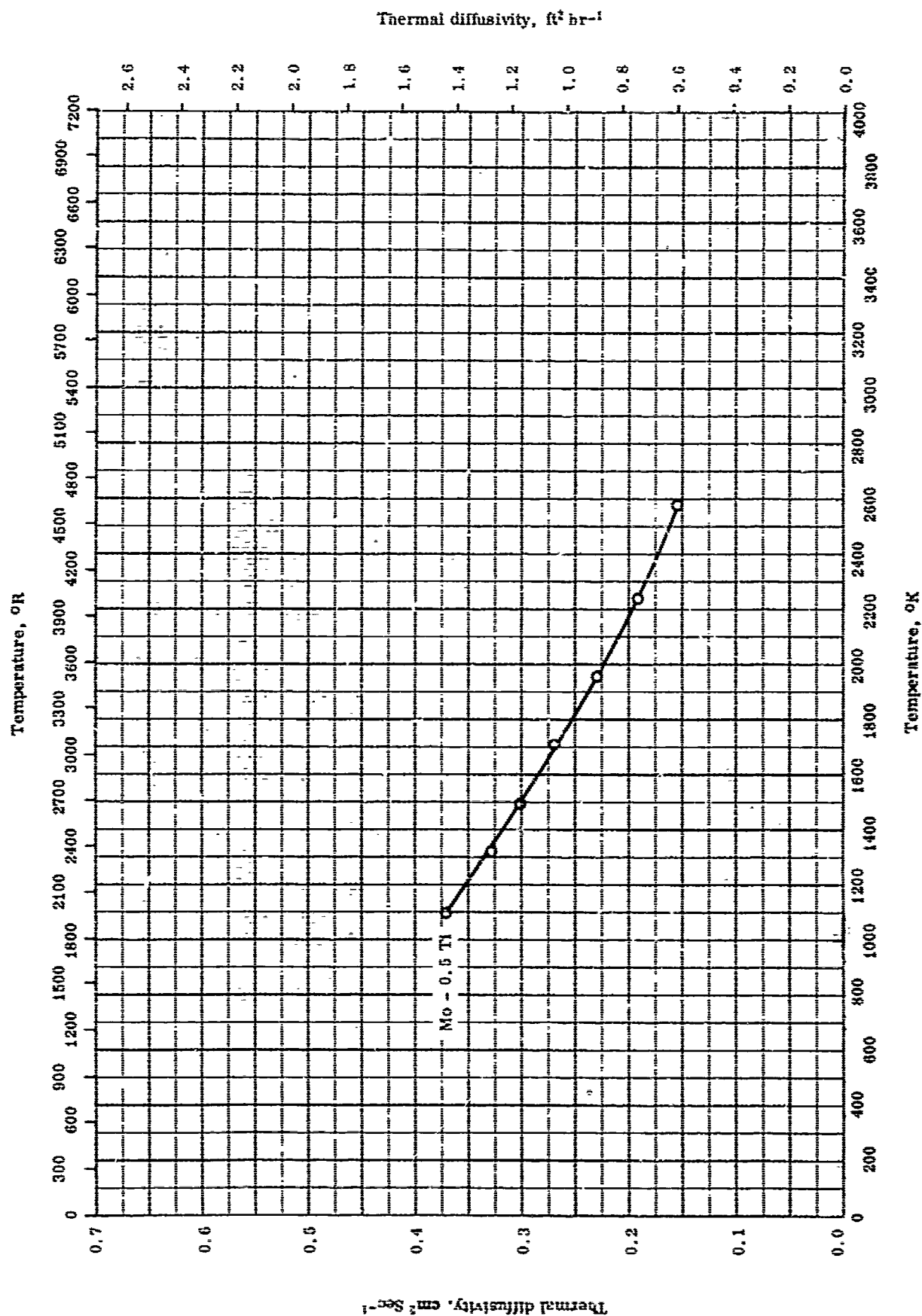
THERMAL CONDUCTIVITY -- MOLYBDENUM + TITANIUM

TPRC

THERMAL CONDUCTIVITY - MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---|
| ○ | 55-6 | 473-1173 | 5 | 99.5 Mo and 0.5 Ti. | Recrystallized at 2700 F; measured in a vacuum of 2×10^{-5} mm Hg. |
| □ | 62-4 | 1233-1863 | 5-7 | Same as above. | Ground and polished to eliminate all the scratches on the surface of sample; heat-soak at 2800 F. |
| △ | 62-4 | 1680-2432 | 5-7 | Same as above. | Same as above; sample found partially melted. |
| ▽ | 62-4 | 1800-2257 | 5-7 | Same as above. | Same as above; sample found unmelted but color changed. |
| ◇ | 63-1 | 344-975 | ±4 | 0.49 Ti, 0.07 Zr, 0.0260 C, 0.001 > Fe, 0.001 > Ni, 0.001 > Si, 0.0001 H ₂ , and 0.0001 N ₂ ; density 622 lb ft ⁻³ . | End-ground to have flat and parallel end surfaces; measured in He atm. |
| ● | 63-1 | 1190-2378 | ±4 | Same as above. | The above sample measured by periodic method in He atm. |
| ■ | 61-6 | 589-1922 | | Same as above. | |



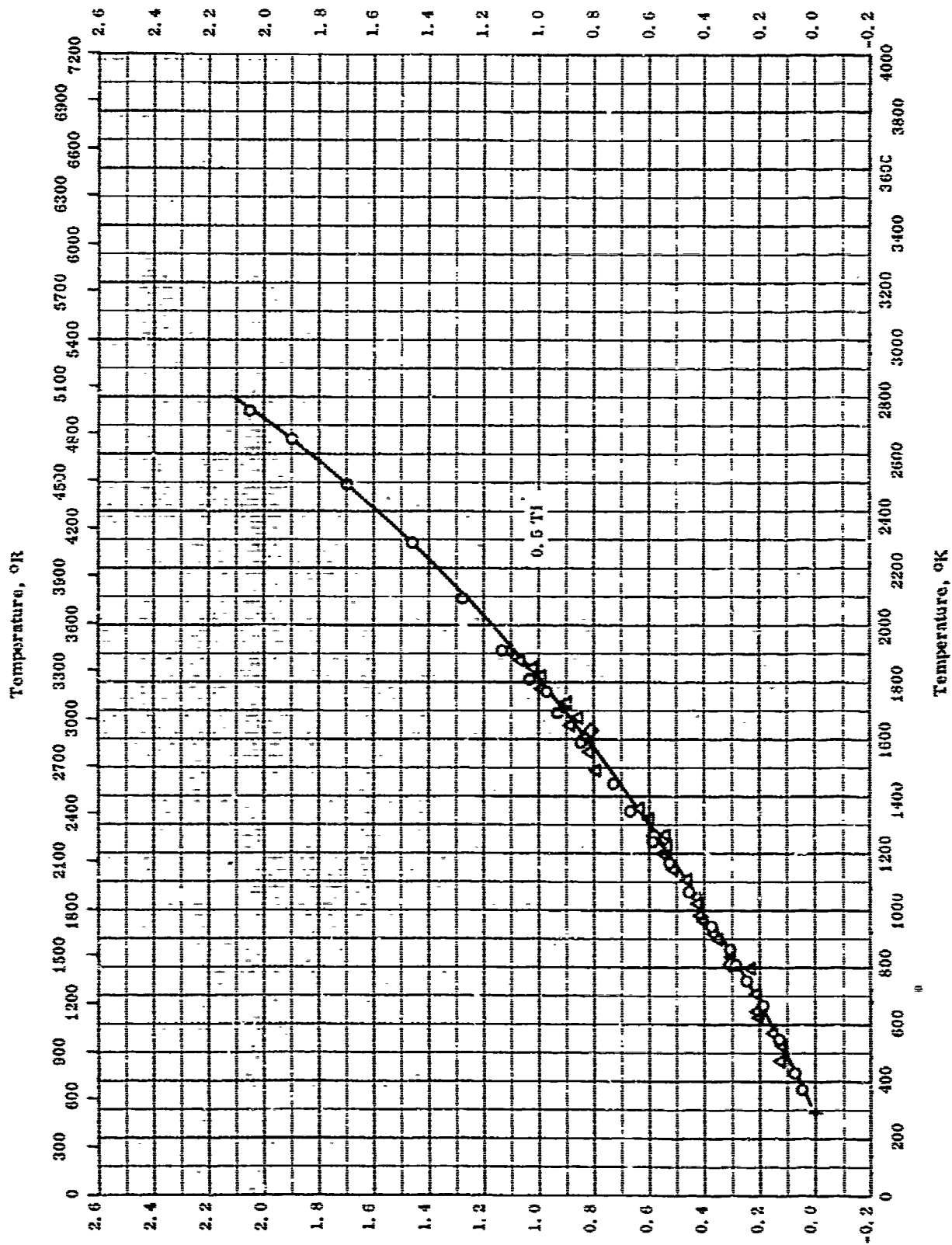
TPRC

THERMAL DIFFUSIVITY --- MOLYBDENUM + TITANIUM

THERMAL DIFFUSIVITY --- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|-----------------------|
| O | 63-1 | 1100-2580 | | 0.49 Ti, 0.07 Zr, 0.026 C, 0.001 > Fe, 0.001 > Ni, 0.001 Si, 0.0007 O ₂ , 0.0001 H ₂ , and 0.0001 N ₂ ; density 9.98 g cm ⁻³ . | Surface ground discs. |



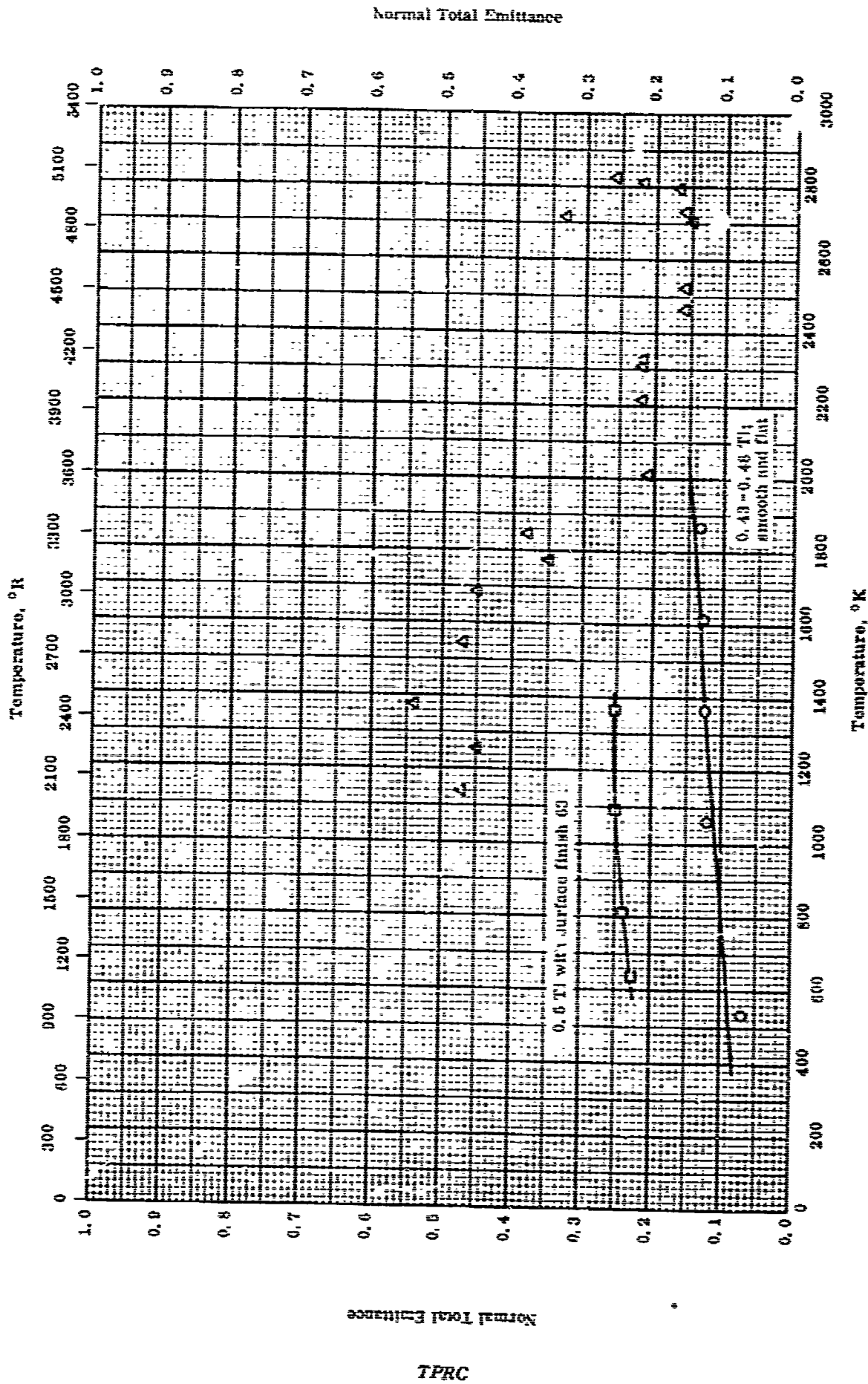
Thermal Linear Expansion -- MOLYBDENUM + TITANIUM

TPRC

THERMAL LINEAR EXPANSION -- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 63-1 | 300-2750 | 2 | Climax Molybdenum Co.: 0.50 Ti, 0.07 Zr, 0.0200 C, < 0.005 Si, < 0.002 Fe, < 0.001 Ni, and traces of O, N, H; density 622 lb ft ⁻³ ; dimension 1/2 in. dia. by 6 in. long. Supplied by General Electric Co., Cleveland, Ohio, nominal composition 0.5 Ti and 0.01 - 0.03 C. 0.5 Ti from Am Metal Climax Co. | Measured in argon with heating rate of approx. 5 F per min. Recrystallized at 2900 F for 35 min. Recrystallized arc-cast billet at 2300 F, reduced approx. 60% by direct rolling, and then machined into 3/8 in. dia. by 3 in. long specimen. |
| △ | 60-11 | 293-1908 | <3 | | |
| ◇ | 60-18 | 300-1610 | <6 | | |



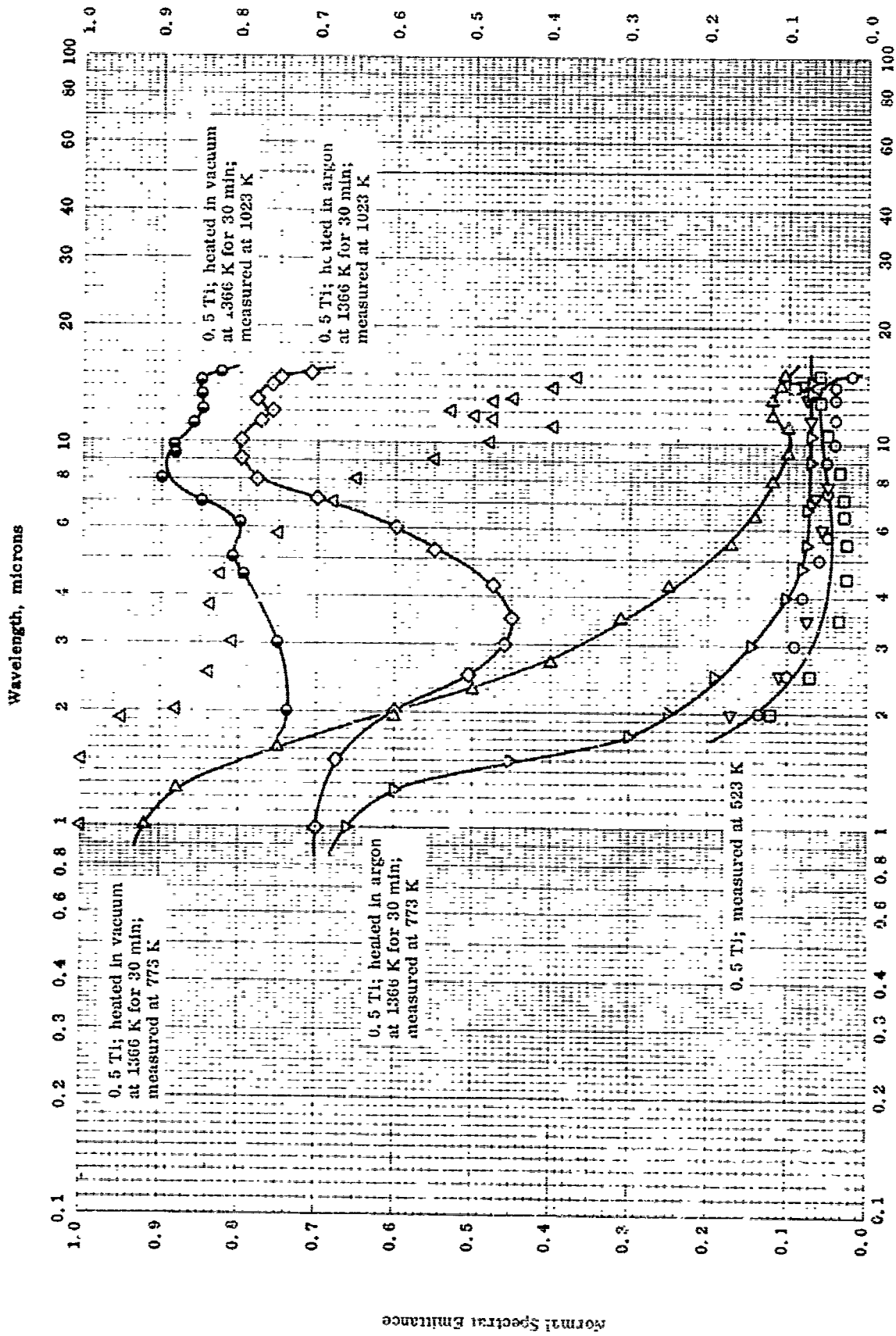
NORMAL TOTAL EMITTANCE - MOLYBDENUM + TITANIUM

NORMAL TOTAL EMITTANCE -- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| C | 60-11 | 533-1866 | ± 5 | 0.43 - 3.43 Ti, 0.024 - 0.31 C and 0.06 others. | Smooth and flat surface; exhibit metallic reflection both before and after heating; heated in an atmosphere of 90 Ar - 10 H ₂ at 78 Cm Hg; averaged over two cycles. |
| Δ | 62-4 | 1688-2716 | 10 | 0.5 Ti. | Measured in argon atmosphere. |
| □ | 60-18 | 644-1366 | | 0.5 Ti; block; surface finish 63. | Measured in moisture removed helium. |

TPRC



Wavelength, microns

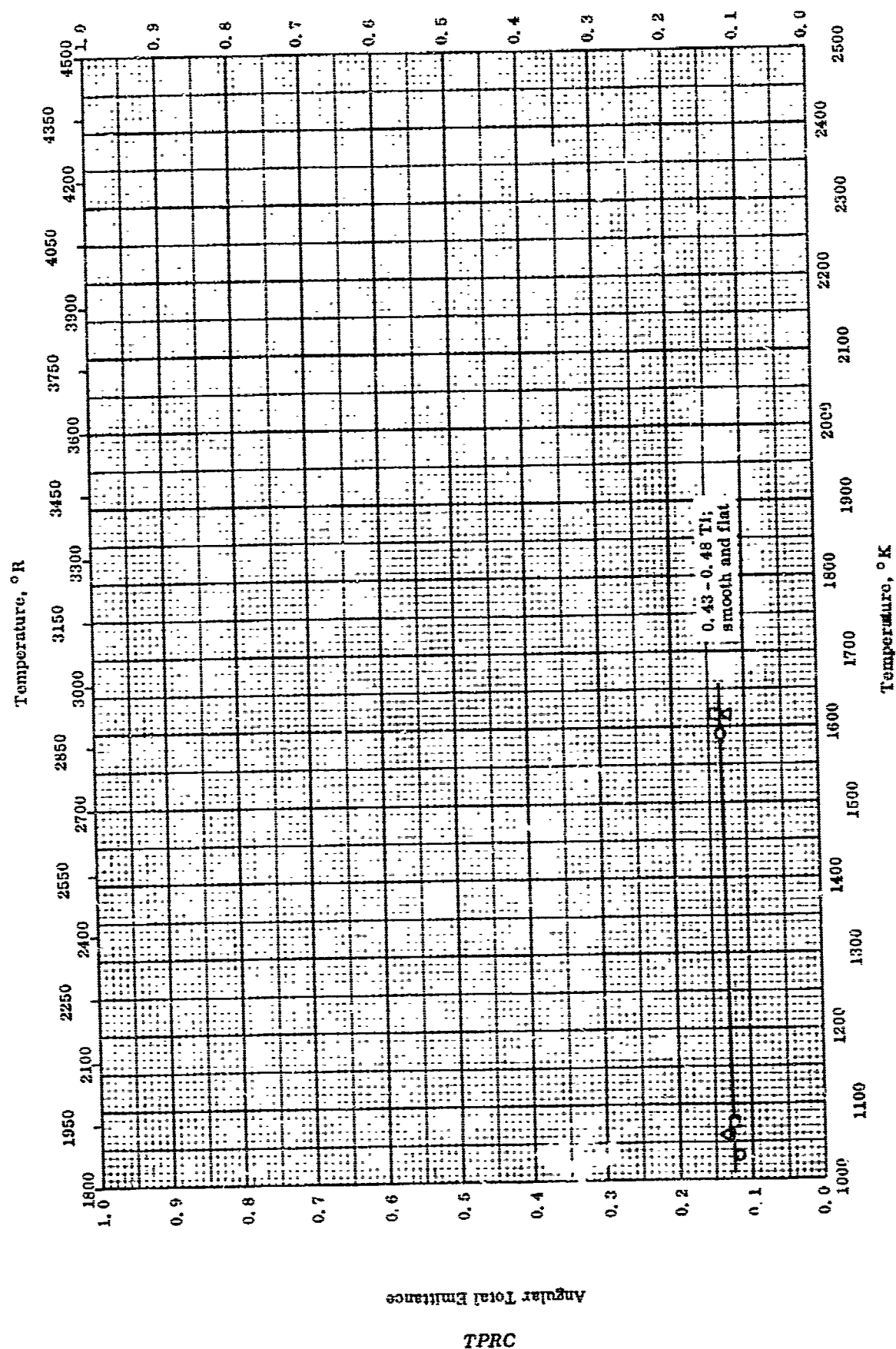
NORMAL SPECTRAL EMITTANCE -- MOLYBDENUM + TITANIUM

NORMAL SPECTRAL EMITTANCE -- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °C | Wavelength Range, μ | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|------------------|---|--|
| ○ | 62-10 | 533.2 | 2.00-15.00 | | 0.5 Ti; commercial; manufactured by Climax Molybdenum Co. | As received. |
| △ | 62-19 | 773.2 | 1.00-15.00 | | Same as above. | As received; another sample. |
| □ | 62-15 | 523.2 | 2.00-15.00 | | Same as above. | Heated in argon at 1366 K for 30 min. |
| ▽ | 62-19 | 773.2 | 1.00-15.00 | | Same as above. | Same as above; another sample. |
| ◇ | 62-19 | 1023 | 1.00-15.00 | | Same as above. | Same as above; another sample. |
| ◁ | 62-19 | 523.2 | 2.00-15.00 | | Same as above. | Heated in a 22×10^{-5} mm Hg vacuum at 1366 K for 30 min. |
| △ | 62-19 | 773.2 | 1.00-15.00 | | Same as above. | Same as above; another sample. |
| ● | 62-19 | 1023 | 2.00-15.00 | | Same as above. | Same as above; another sample. |

TPRC



ANGULAR TOTAL EMITTANCE -- MOLYBDENUM + TITANIUM

ANGULAR TOTAL EMITTANCE -- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|---|--|
| ○ | 60-11 | 1333-1589 | ±5 | 0.43 - 0.46 Ti, 0.024 - 0.31 C and 0.06 others, | Measured in argon-hydrogen atmosphere; 30° from normal. |
| △ | 60-11 | 1061-1016 | ±5 | 0.43 - 0.48 Ti, 0.024 - 0.31 C and 0.06 others. | Measured in argon-hydrogen atmosphere; 45° from normal. |
| □ | 60-11 | 1075-1616 | ±5 | 0.43 - 0.48 Ti, 0.024 - 0.31 C and 0.06 others. | Measured in argon-hydrogen atmosphere; 60° from normal. |

TPRC

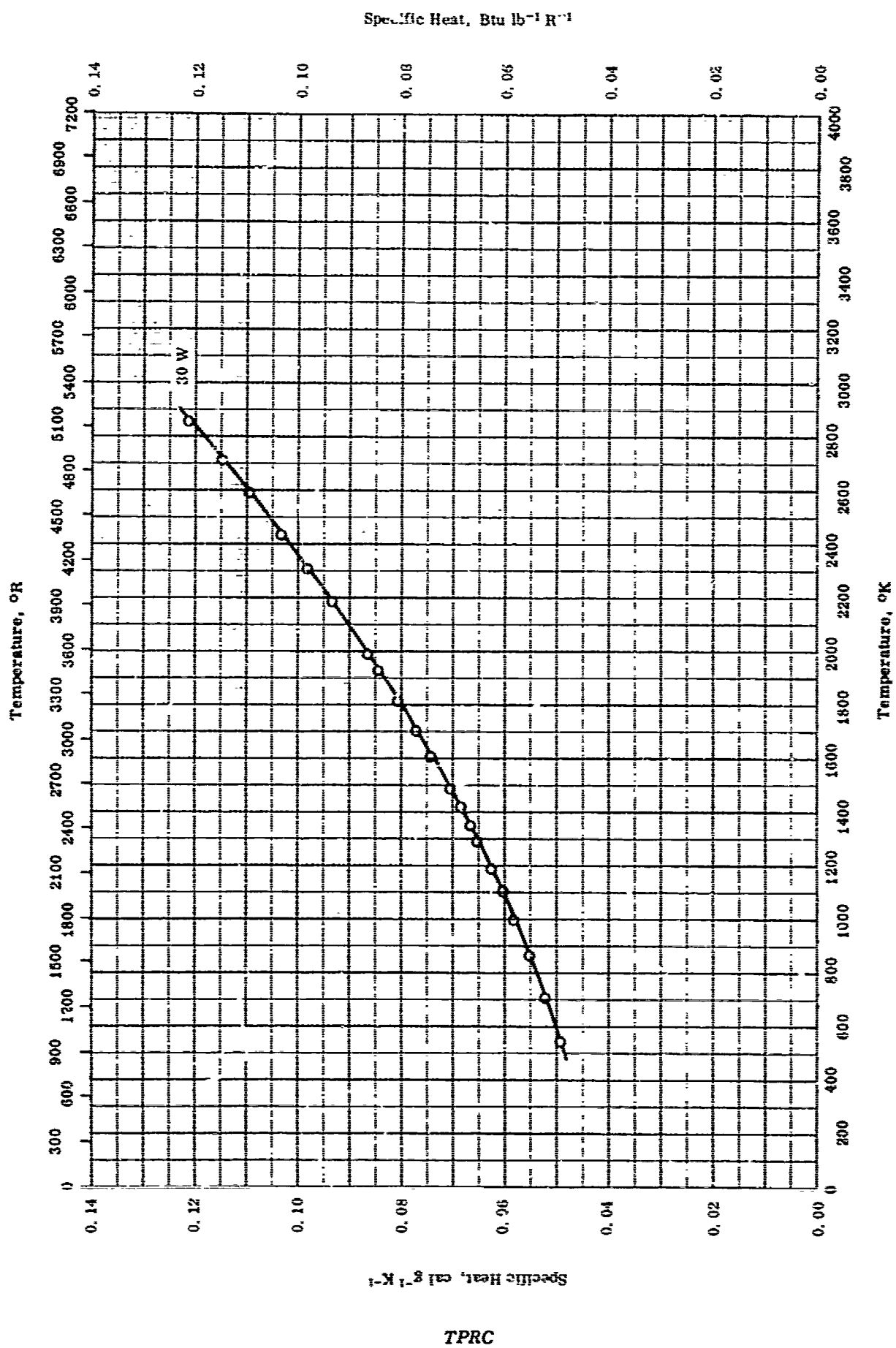


NORMAL SPECTRAL REFLECTANCE -- MOLYBDENUM + TITANIUM

NORMAL SPECTRAL REFLECTANCE --- MOLYBDENUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|------------------|---|--|
| ○ | 62-19 | <322 | 2.0-15.00 | | 0.5 Ti; commercial; manufactured by Climax Molybdenum Co. | As received; 523.2 K source; hemispherical illumination and normal viewing. |
| △ | 62-19 | <322 | 1.00-15.00 | | Same as above. | As received; 773.2 K source; hemispherical illumination and normal viewing. |
| □ | 62-19 | <322 | 0.50-15.00 | | Same as above. | As received; 1273 K source; hemispherical illumination and normal viewing. |
| ▽ | 62-19 | <322 | 2.00-15.00 | | Same as above. | Heated in argon at 1333 K for 0.5 hr.; 523.2 K source; hemispherical illumination and normal viewing. |
| ◇ | 62-19 | <322 | 1.00-15.00 | | Same as above. | Heated in argon at 1366 K for 30 min.; 773.2 K source; hemispherical illumination and normal viewing. |
| ◁ | 62-19 | <322 | 0.50-15.00 | | Same as above. | Heated in argon at 1366 K for 30 min.; 1273.2 K source; hemispherical illumination and normal viewing. |
| ▷ | 62-19 | <322 | 2.00-15.00 | | Same as above. | Heated in a 22×10^{-5} mm Hg vacuum at 1366 K for 30 min.; 523.2 K source; hemispherical illumination and normal viewing. |
| ● | 62-19 | <322 | 1.00-14.00 | | Same as above. | Same as above except with 773.2 K source. |
| ▲ | 62-19 | <322 | 0.500-15.00 | | Same as above. | Same as above except with 1273 K source. |



SPECIFIC HEAT -- MOLYBDENUM + TUNGSTEN

SPECIFIC HEAT -- MOLYBDENUM + TUNGSTEN

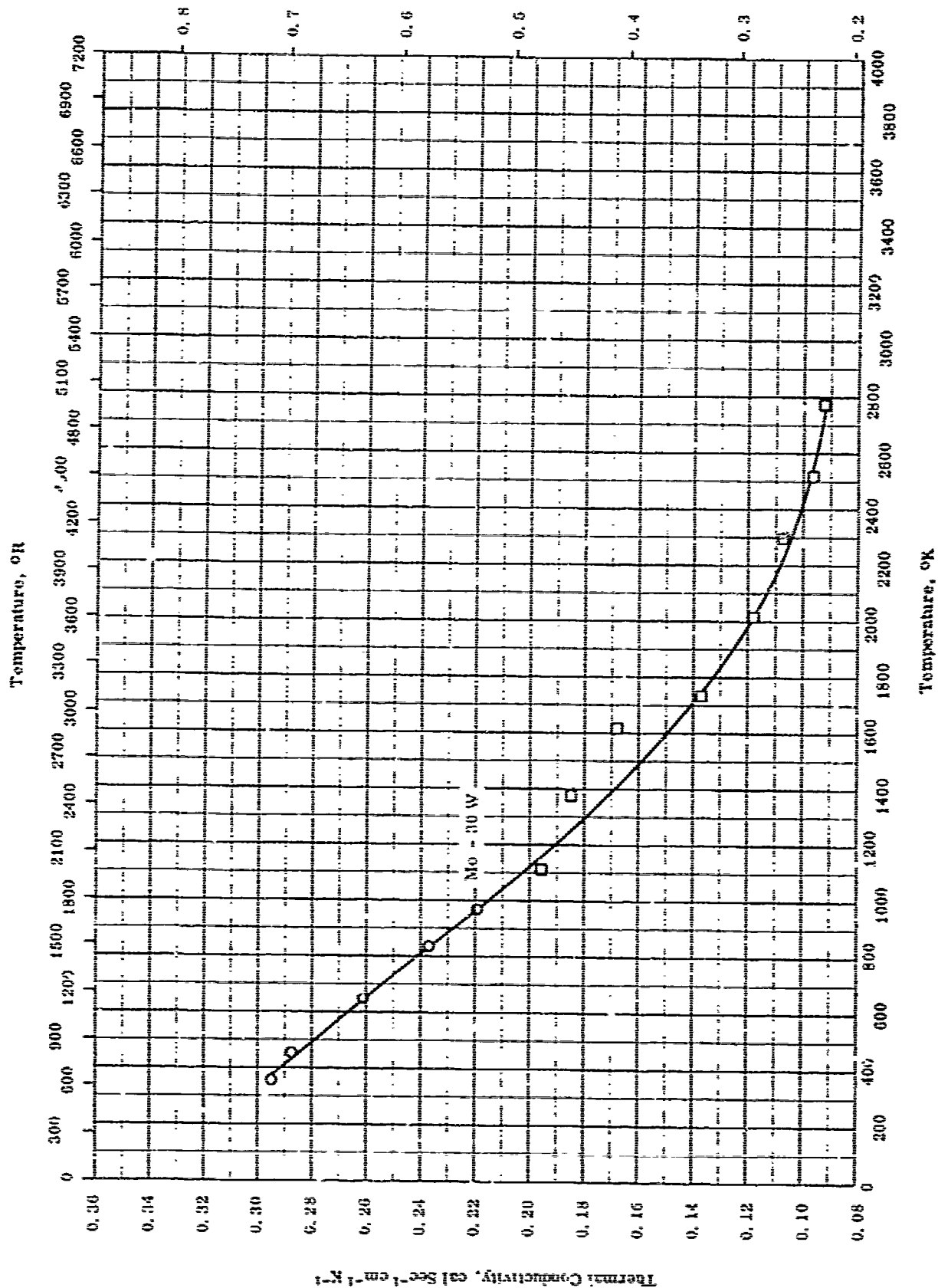
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Aspt. Error, % | Sample Specifications | Remarks |
|------------|------|--------------------|-------------------|--|---------|
| O | 03-1 | 520-2850 | ± 5.0 | Mo-29.83 W - 0.07 Zr - 0.012 C alloy; 29.83 W, 0.07 Cr, 0.012 C. | |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

313



THERMAL CONDUCTIVITY -- MOLYBDENUM + TUNGSTEN

TPRC

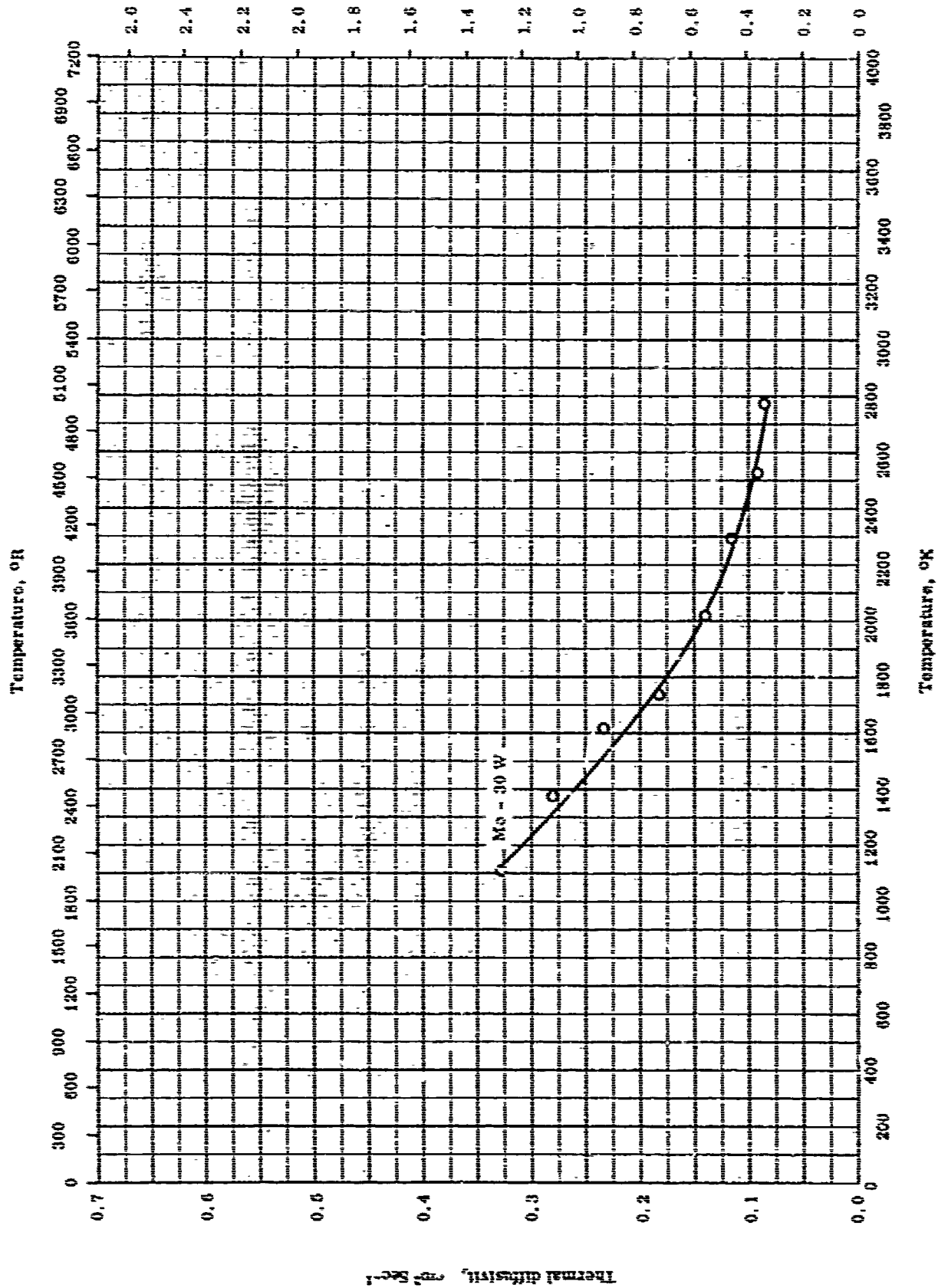
THERMAL CONDUCTIVITY -- MOLYBDENUM + TUNGSTEN

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|--|
| ○ | 63-1 | 358-964 | ± 4 | 29.83 W, 0.07 Zr, and 0.0120 C; density 620 lb ft ⁻³ . | End faces ground flat and parallel; measured in He atm. |
| □ | 63-1 | 1110-2772 | ± 4 | Same as above. | Same as above except measured by another method. |

Thermal diffusivity, $\text{ft}^2 \text{hr}^{-1}$

315



THERMAL DIFFUSIVITY -- MOLYBDENUM + TUNGSTEN

THERMAL DIFFUSIVITY -- MOLYBDENUM + TUNGSTEN

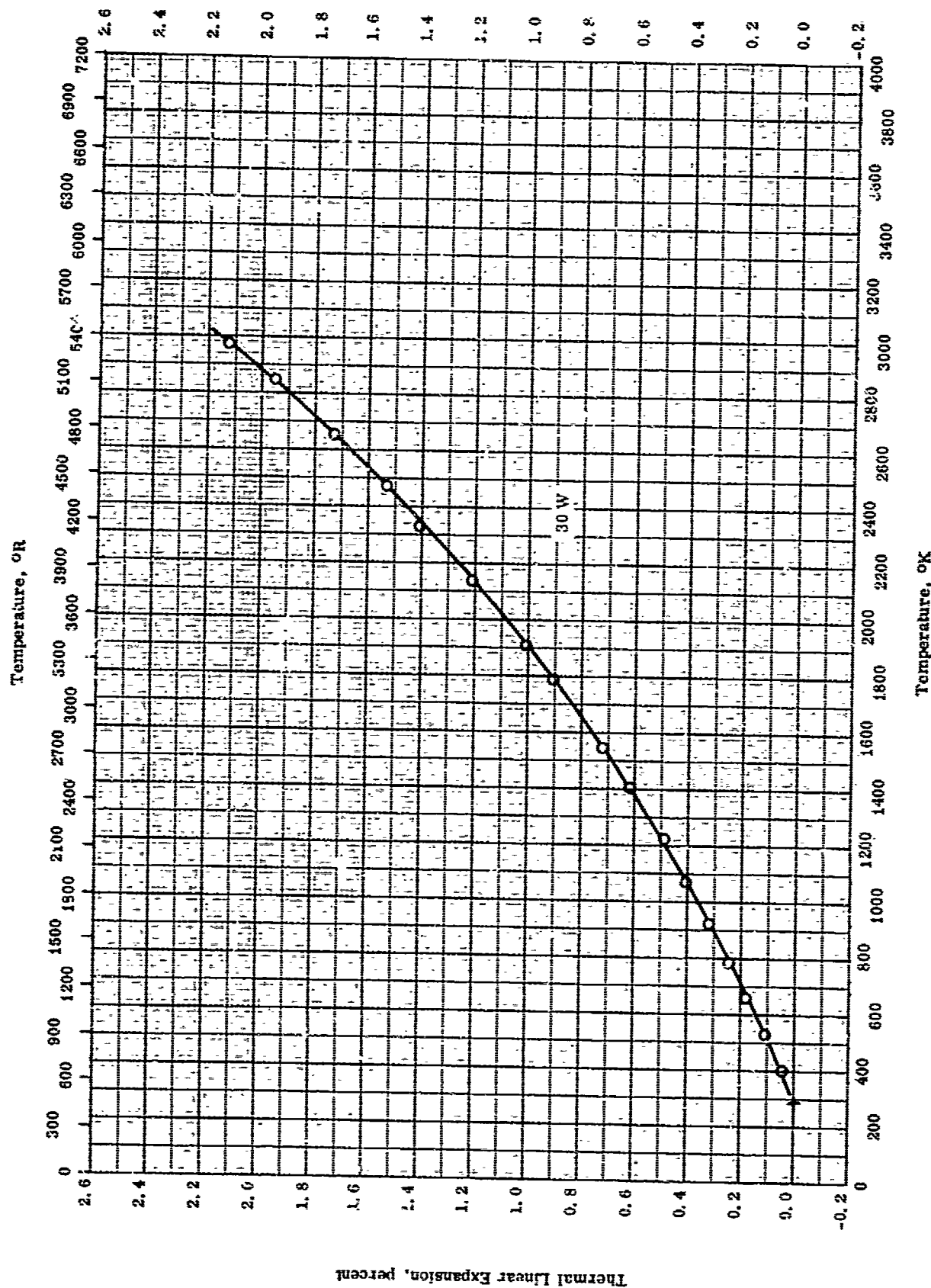
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|-----------------------|
| O | 63-1 | 1111-2774 | | 70.088 Mo, 29.83 W, 0.07 %r, and 0.012 C; density 9.93 g cm ⁻³ | Surface ground disks. |

TPRC

Thermal Linear Expansion, percent

317



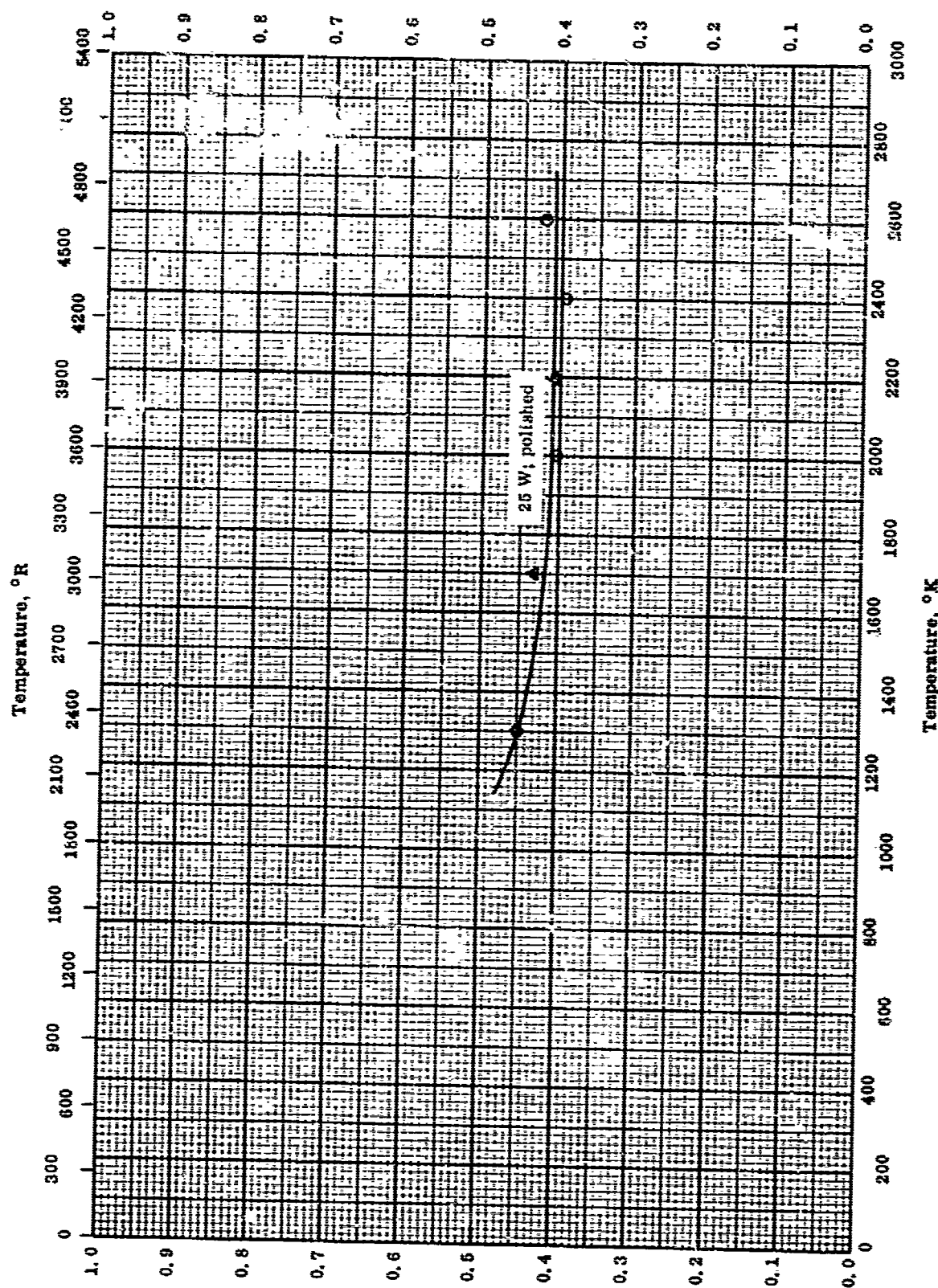
THERMAL LINEAR EXPANSION -- MOLYBDENUM + TUNGSTEN

TPRC

THERMAL LINEAR EXPANSION -- MOLYBDENUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|--|
| O | 63-1 | 300-2973 | 2 | Climax Molybdenum Co.; 70.09 Mo, 29.83 W, 0.07 Zr, and 0.0120 C; density 620 lb ft ⁻³ ; specimen dimension 1/2 in. dia. by 6 in. long. | Measured in argon with heating rate of approx. 5 F per min. |



NORMAL SPECTRAL EMITTANCE --- MOLYBDENUM + TUNGSTEN

Normal Spectral Emittance

TPRC

NORMAL SPECTRAL EMITTANCE -- MOLYBDENUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. Range K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|---------------------|------------------|------------------|-------------------------|---|
| O | 33-1 | 0.660 | 1300-2600 | ± 2 | 75 Mo and 25 W. | Electrolytically polished in KO ₂ solution, further polish using 00,000 and 0000 polishing papers. |
| Δ | 36-2 | 0.660 | 1300-2400 | ± 2 | 25 W; tubular filament. | Formed from powdered metal, sintered; electrolytically polished in KOH bath. |

PROPERTIES OF NEPTUNIUM + URANIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-------------------------------|--------------------|---------------------|
| $\Delta \quad 0.20 \text{ U}$ | 19.5 ± 0.6 | 1220 ± 35 |
| Melting Point: | K | R |
| $\nabla \quad 0.20 \text{ U}$ | 913 ± 1 | 1644 ± 2 |

PROPERTIES OF NEPTUNIUM + URANIUM

REFERENCE INFORMATION

| Sym Cool | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|-------|-------------------|------------------|--|---|
| Δ | 50-16 | 298 | | 0.2 U, 0.08 Fe, 0.02 Cu, and 0.013 Ba. | Ba reduced from Np F ₃ ; density by measuring weight and volume of displacement of liquid. |
| ✓ | 50-16 | 912-916 | | Same as above. | |

PROPERTIES OF NEODYMIUM + MAGNESIUM

REPORTED VALUES

| Density | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| O 1.0 Mg | 6.9 | 423 |

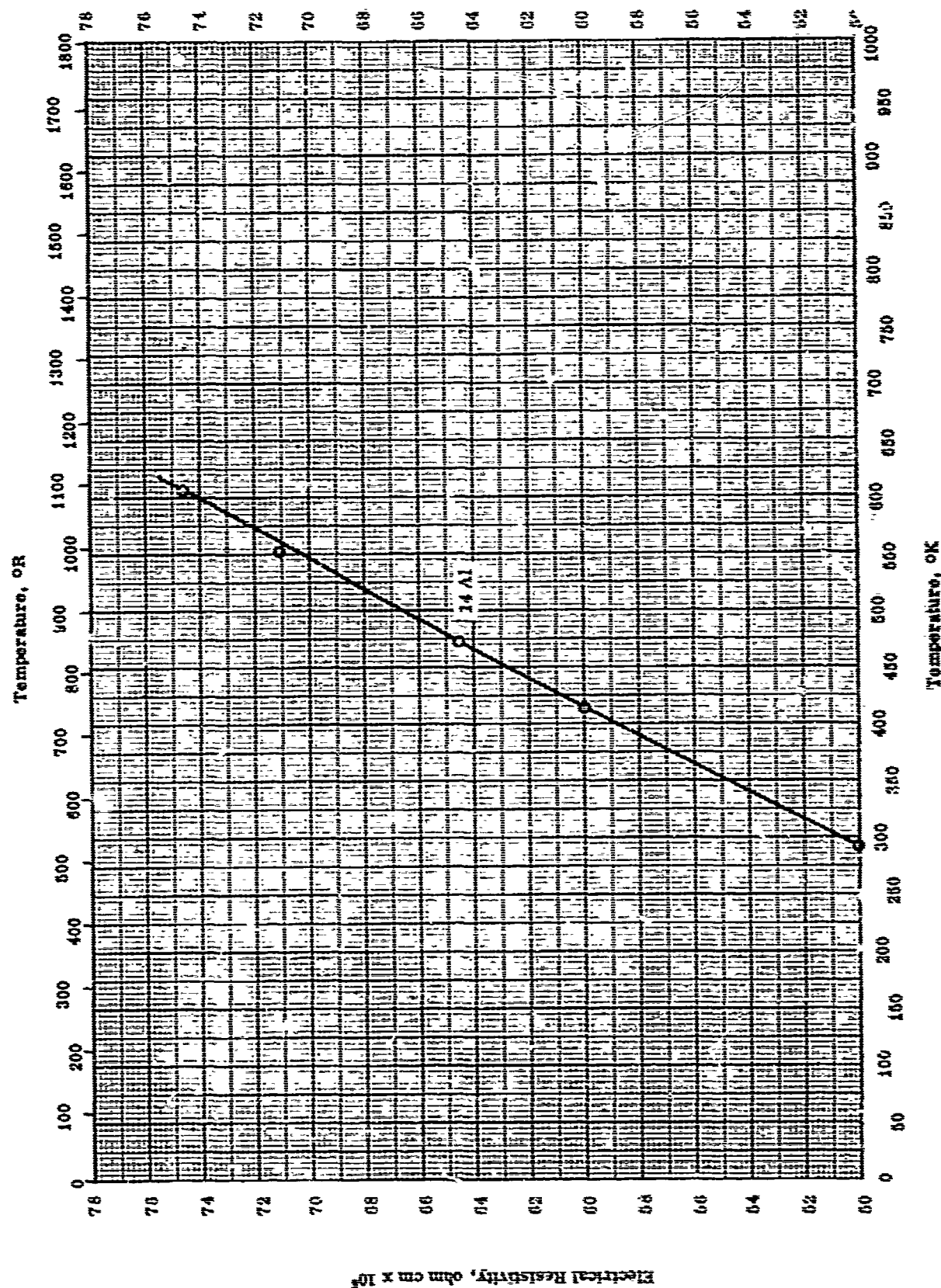
PROPERTIES OF NEODYMIUM + MAGNESIUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| Q | 52-11 | 298 | | 1.0 > Mg, 0.025 > Ca, 0.0178 Fe, 0.01 > other rare earth; entirely hexagonal close packed phase. | Cast then annealed for 19 hrs at 600 C. |

Electrical Resistivity, ohm cm $\times 10^4$

325



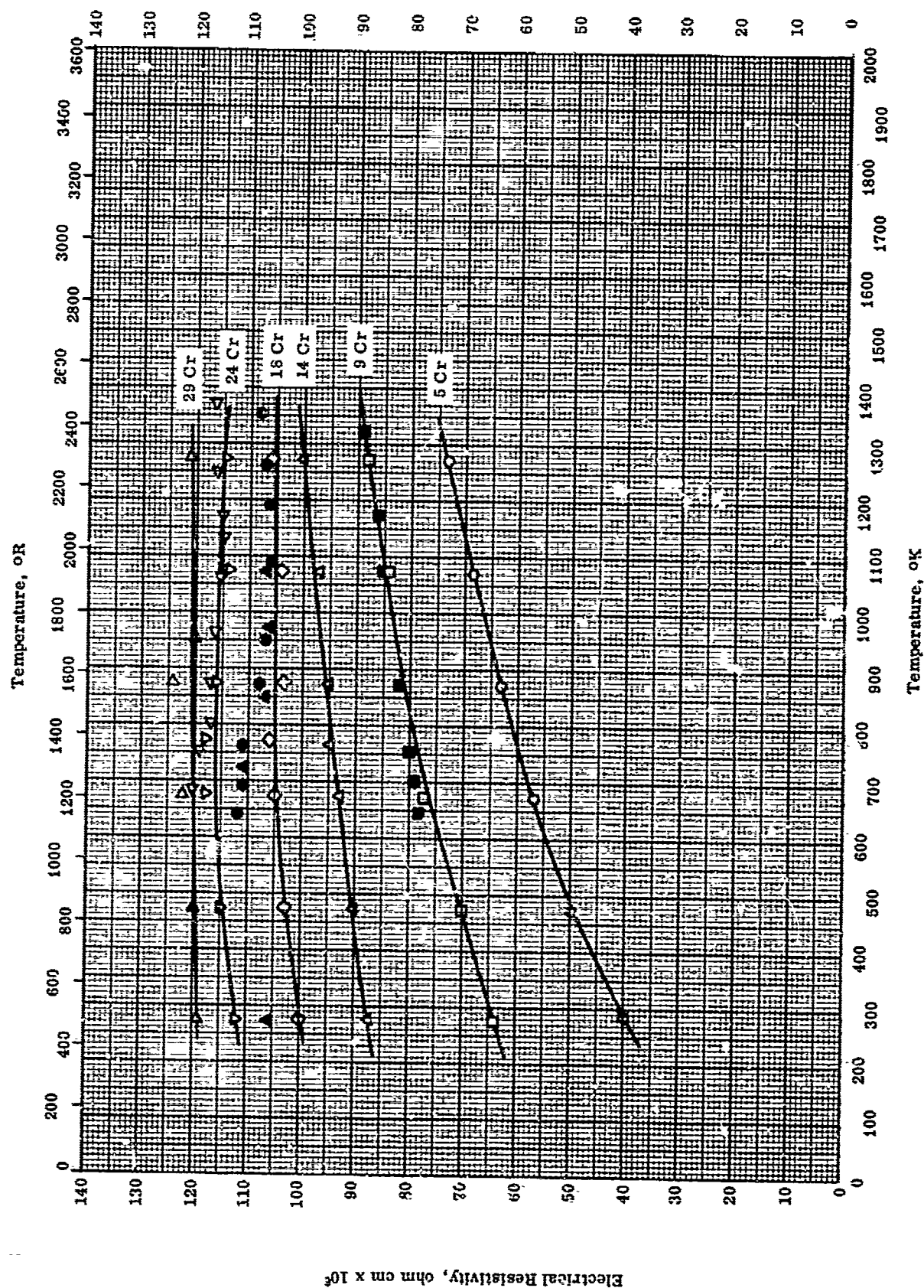
ELECTRICAL RESISTIVITY -- NICKEL + ALUMINUM

ELECTRICAL RESISTIVITY -- NICKEL + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 54-18 | 293-605 | | 86.2 Ni and 13.8 Al; prepared from 99.99 pure Mond carbonyl process Ni with 0.10 > C and 0.001 > Co and 99.99 pure Al with 0.001 each Cu, Fe, Si. | Heat treated 72 hrs at 1100 C, furnace cooled. |

TFRC



ELECTRICAL RESISTIVITY --- NICKEL + CHROMIUM

TPRC

ELECTRICAL RESISTIVITY -- NICKEL + CHROMIUM

REFERENCE INFORMATION

| Sym. Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|-------|-------------------|------------------|--|--|
| ○ | 51-11 | 288-1273 | | Nominal: 95.15 Ni and 4.85 Cr. | Vacuum melted, forged, rolled, and then cold drawn into 0.4 mm wires. |
| □ | 51-11 | 273-1273 | | Nominal: 90.8 Ni and 9.2 Cr. | Same as above. |
| △ | 51-11 | 273-1273 | | Nominal: 85.6 Ni and 14.4 Cr. | Same as above. |
| ◇ | 51-11 | 273-1273 | | Nominal: 81.9 Ni and 18.1 Cr. | Same as above. |
| ▽ | 51-11 | 273-1273 | | Nominal: 76 Ni and 24 Cr. | Same as above. |
| △ | 51-11 | 273-1273 | | Nominal: 71.1 Ni and 28.9 Cr. | Same as above. |
| ▽ | 54-15 | 683-1373 | | 70.6 Ni and 29.4 Cr; prepared from Mond Ni and electrolytic Cr. | Cr annealed at 1250 C in H ₂ atmos. for 100 hrs to decrease O ₂ and C content. |
| ● | 54-15 | 643-1353 | | 79.8 Ni, 20.2 Cr, 0.03 O ₂ , 0.005 N ₂ , 0.002 C, and 0.002 S. | Same as above. |
| ■ | 54-15 | 643-1323 | | 80.2 Ni, and 9.8 Cr. | Same as above. |
| ▲ | 57-31 | 273-1173 | ±0.1 | 18.1 Cr, 0.6 > Mn, and 0.3 > Si. | 50% cold reduced by rolling; tempered 7 days at 435 C. |

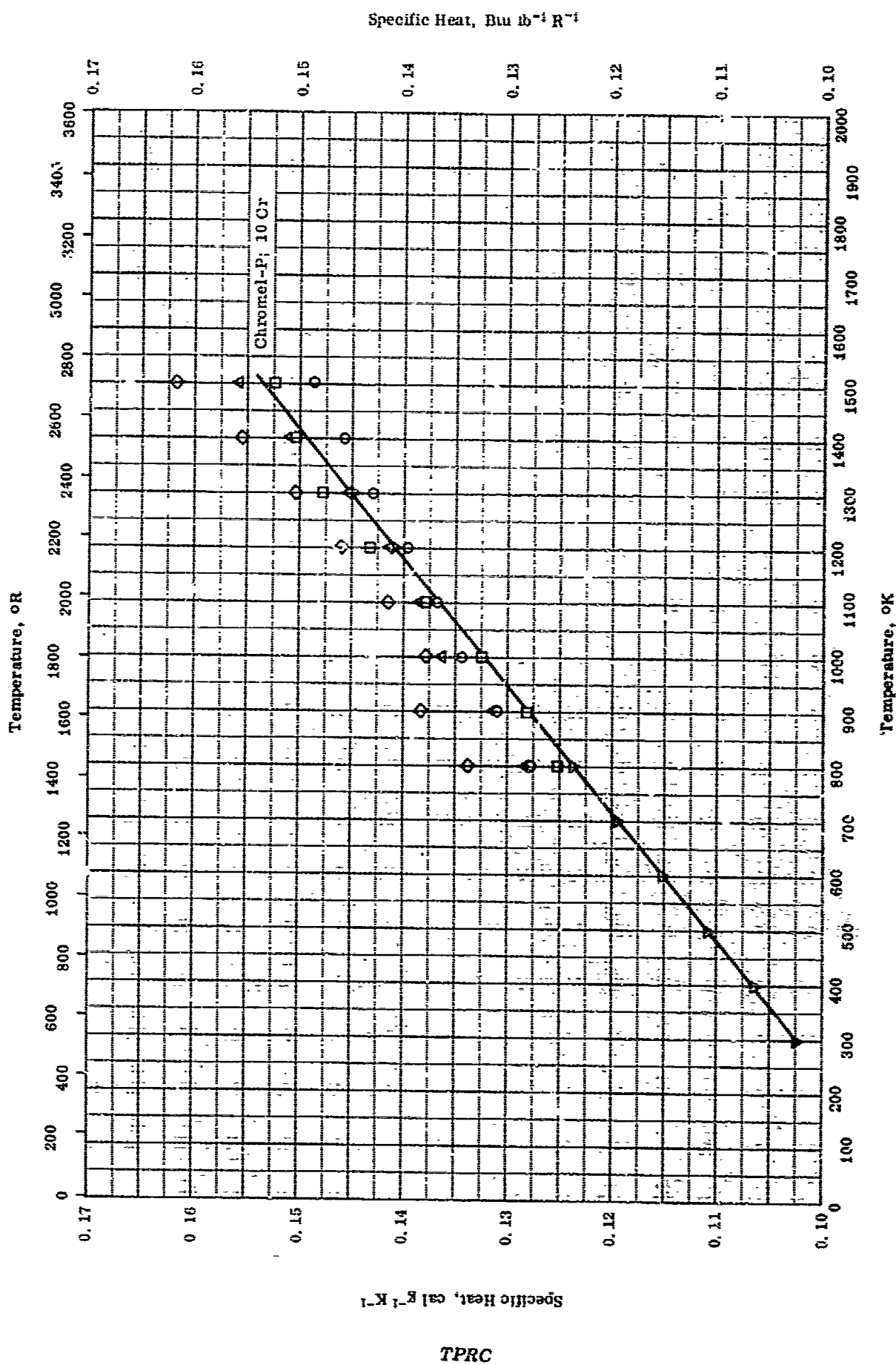


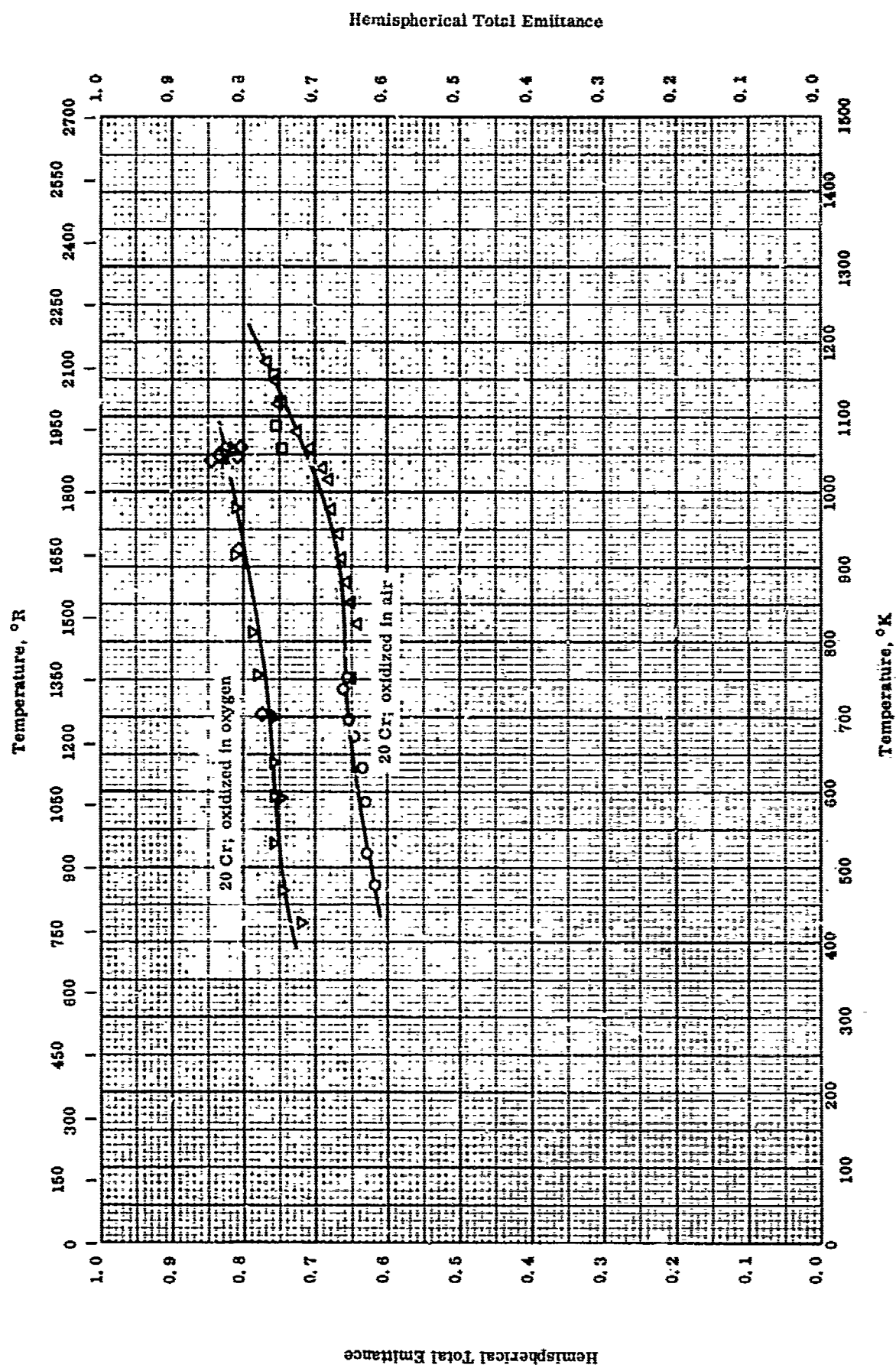
Fig. 1. Specific Heat of Nickel + Chromium

SPECIFIC HEAT -- NICKEL + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|-------------------------|
| ○ | 59-12 | 800-1500 | ± 0.3 | Ni ₉₀ 8818Cr ₁₀ 0125; 98.39 Ni and 1.61 Cr. | Under argon atmosphere. |
| □ | 59-12 | 800-1500 | ± 0.3 | Ni ₉₀ 8853Cr ₁₀ 0227; 97.81 Ni and 2.19 Cr. | Same as above. |
| △ | 59-12 | 800-1500 | ± 0.3 | Ni ₉₀ 8872Cr ₁₀ 0438; 96.09 Ni and 3.91 Cr. | Same as above. |
| ◇ | 59-12 | 800-1500 | ± 0.3 | Ni ₉₀ 8887Cr ₁₀ 1103; 90.08 Ni and 9.92 Cr. | Same as above. |
| ▽ | 63-13 | 298-1600 | | Chromel-P; 90 Ni and 10 Cr. | |

TPRC

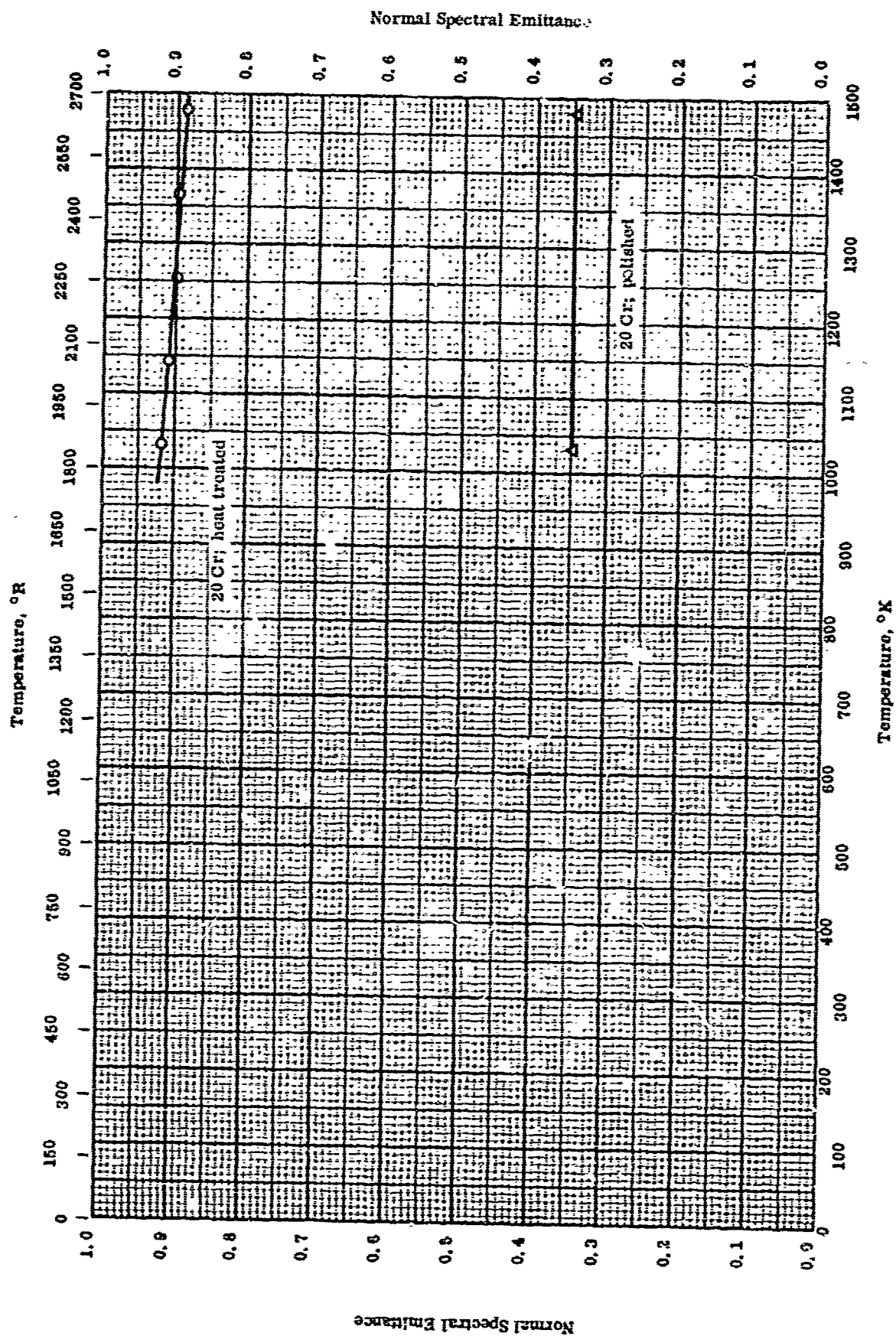


HEMISPHERICAL TOTAL EMITTANCE -- NICKEL + CHROMIUM

HEMISPHERICAL TOTAL EMITTANCE -- NICKEL + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|----------------------------|--|
| ○ | 64-6 | 477-753 | | Nichrome; 80 Ni and 20 Cr. | Oxidized in air at 1800 F for 2 hrs; first run. |
| △ | 64-6 | 751-1174 | | Same as above. | Same as above; second heating. |
| □ | 64-6 | 1000-1157 | | Same as above. | Same as above; second cooling. |
| ▽ | 64-6 | 427-1035 | | Same as above. | Oxidized in oxygen at 1800 F for 1/4 hr.; first run. |
| ◇ | 64-6 | 705-1059 | | Same as above. | Same as above; second run. |



TPRC

NORMAL SPECTRAL EMITTANCE --- NICKEL + CHROMIUM

NORMAL SPECTRAL EMITTANCE -- NICKEL + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. Range, °K | Rept. Error% | Sample Specifications | Remarks |
|------------|------|---------------------|--------------------|-----------------|-----------------------|--|
| O | 39-2 | 0.65 | 1033-1589 | 2 | 80 Ni and 20 Cr; bar. | Polished with rouge paper; heat 2 hrs at 1478 K; measured in air. |
| Δ | 39-2 | 0.65 | 1033-1478 | 2 | 80 Ni and 20 Cr; bar. | Polished with rouge paper; measured in purified hydrogen; emittance constant over the temperature range from 1033 K to 1478 K. |

PROPERTIES OF NICKEL + COBALT

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| ○ 20 Co | 8.89 | 555.3 |
| □ 40 Co | 8.87 | 554.3 |

PROPERTIES OF NICKEL + COBALT

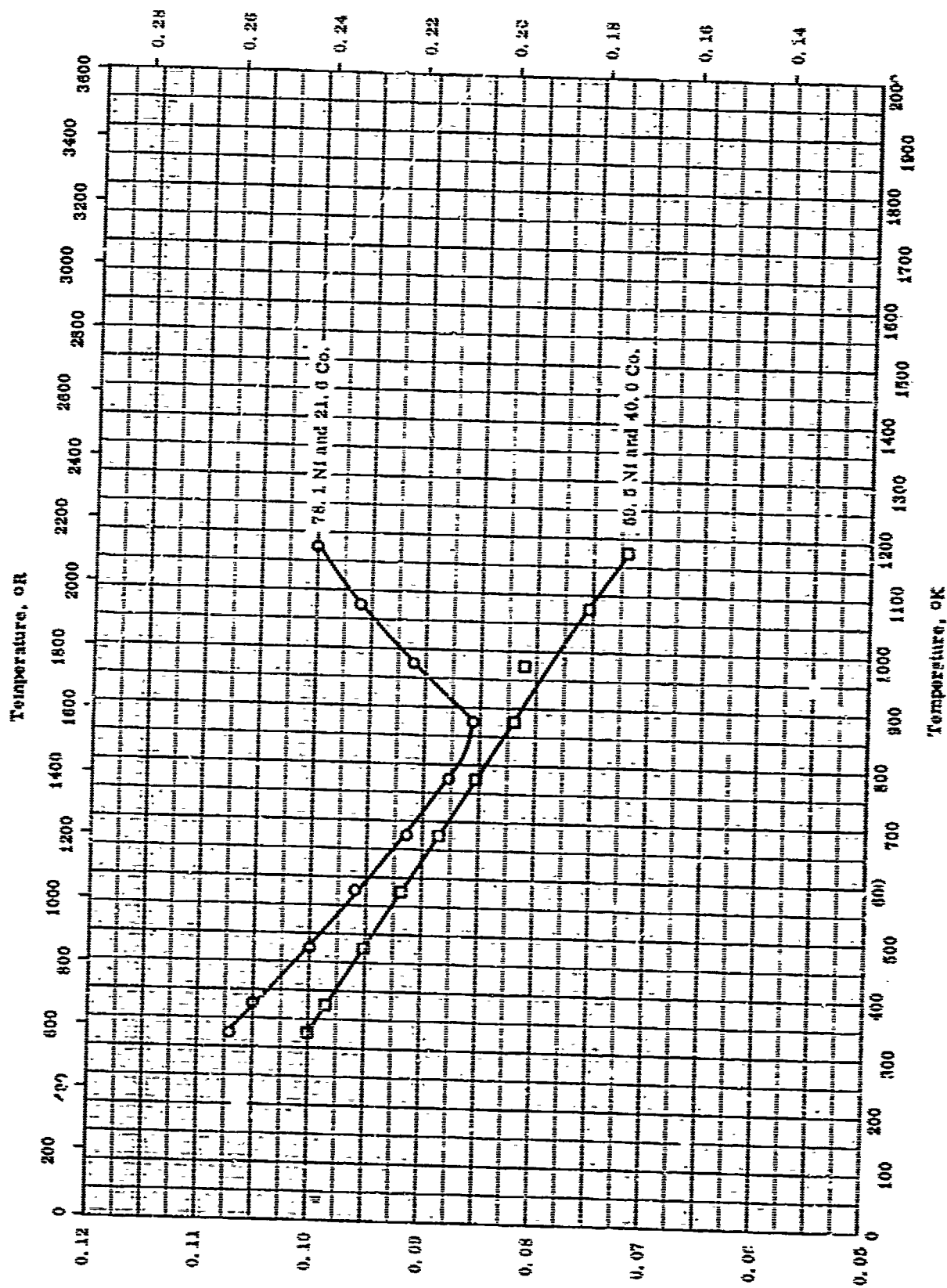
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Expt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 50-12 | 258 | | 20 Co; made from 99.92 electrolytic Ni (0.037 Fe, 0.030 Co, 0.023 As, 0.020 Cu, 0.01 C, 0.009 P, and 0.001 each Si and Mn). | Melted in alumina tube; forged, annealed, rolled annealed, machined to size, and annealed 2 hrs at 1100 C. |
| □ | 50-12 | 298 | | 40 Co; same as above. | Same as above. |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

337



Thermal Conductivity, $\text{cal Sec}^{-1} \text{cm}^{-1} \text{K}^{-1}$

TPRC

Thermal Conductivity -- NICKEL + COBALT

THERMAL CONDUCTIVITY -- NICKEL + COBALT

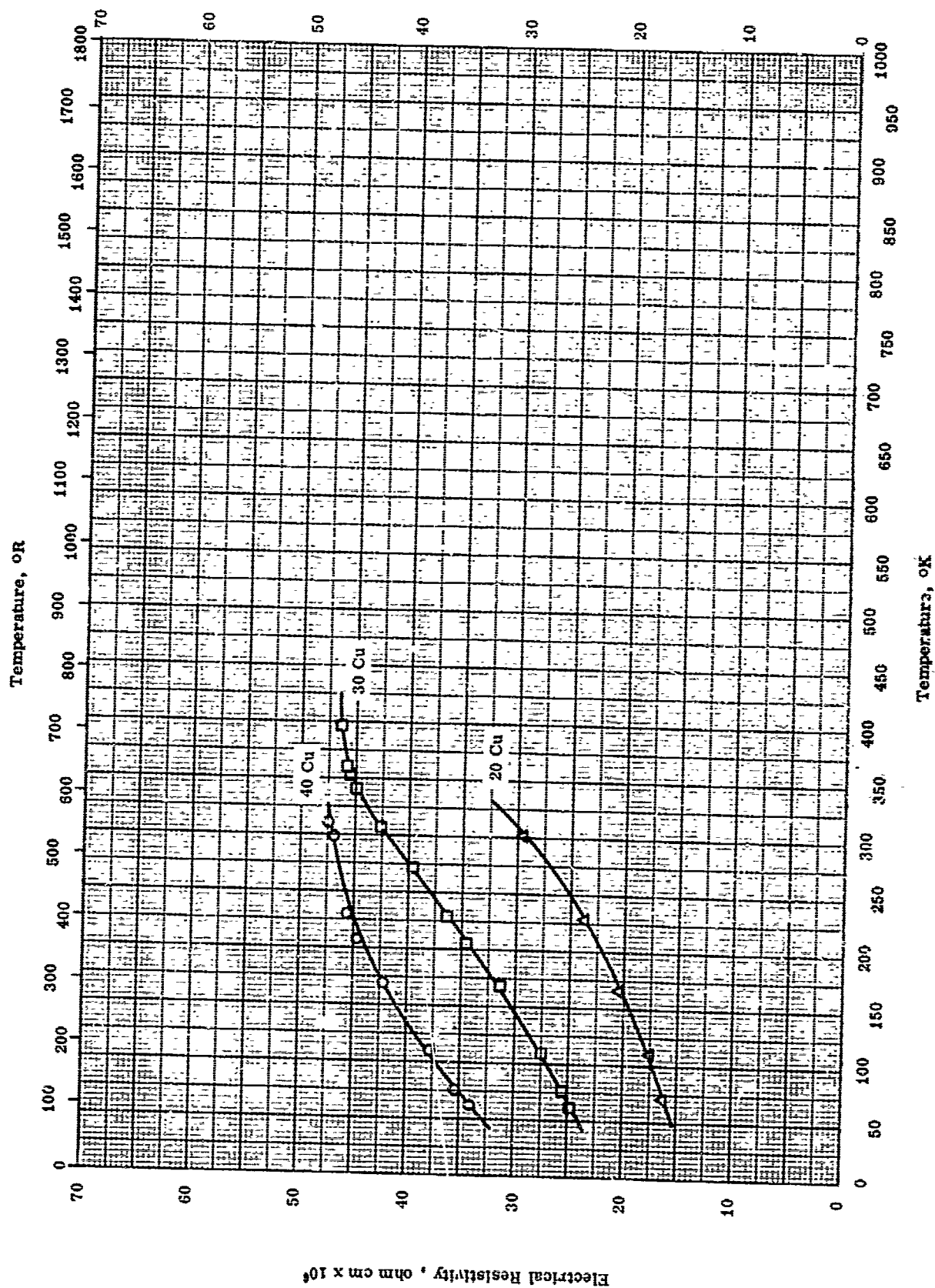
REFERENCE INFORMATION

| Sym- bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|------|-------------------|------------------|---|---------|
| ○ | 53-2 | 325-1173 | | RCA-N97; 78.1 Ni, 21.6 Co, 0.105 Mn, 0.115 C, and 0.01 Mg. | |
| □ | 53-2 | 323-1173 | | RCA-N91; 59.5 Ni, 40.0 Co, 0.19 Si, 0.175 Mn, 0.132 C, and 0.01 Mg. | |

TPRC

Electrical Resistivity, ohm cm x 10⁶

339

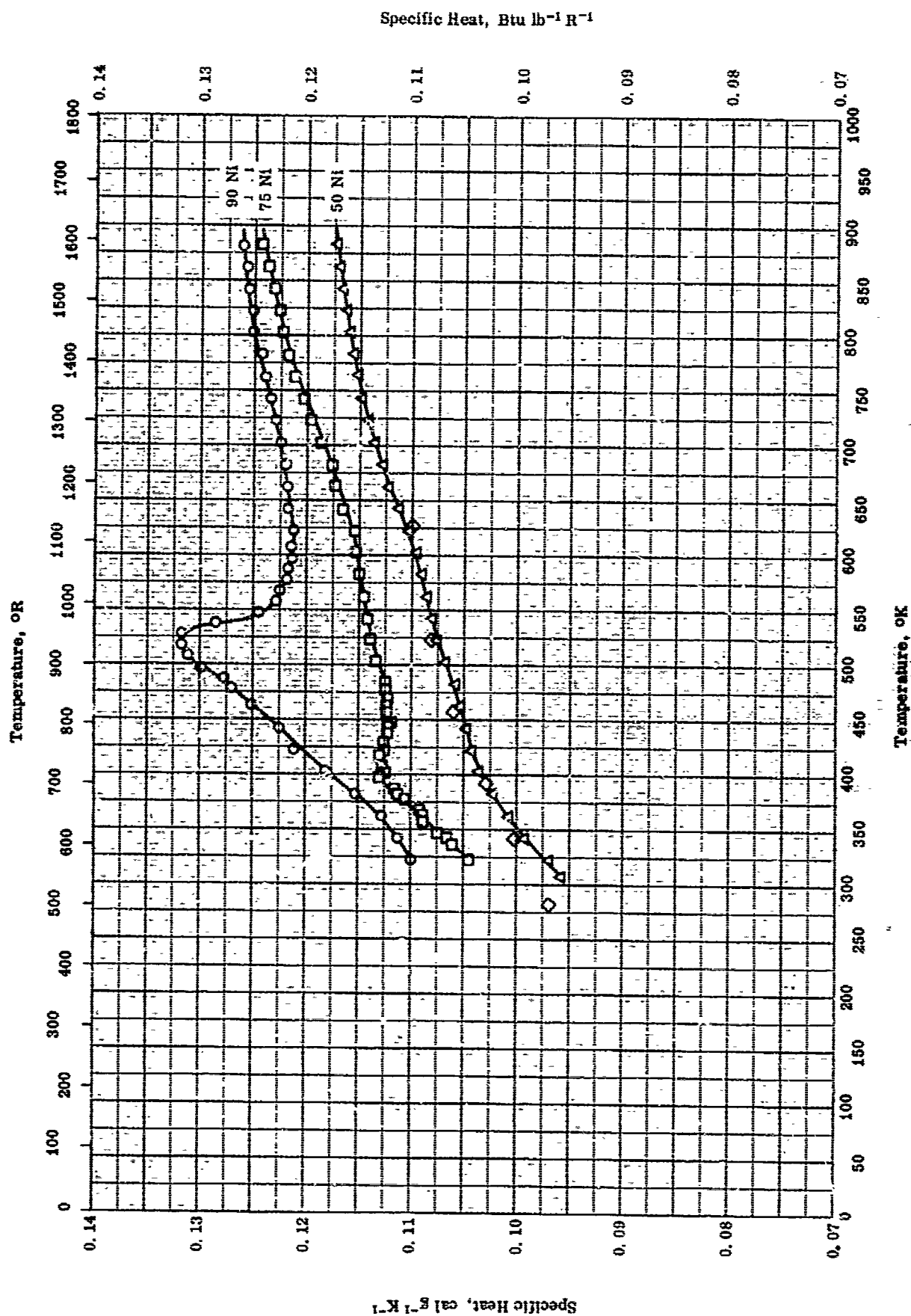


ELECTRICAL RESISTIVITY -- NICKEL + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|-----------------------|---------|
| ○ | 56-21 also 56-22 | 64-310 | | 60 Ni and 40 Cu. | |
| □ | 56-21 also 56-22 | 64-399 | | 70 Ni and 30 Cu. | |
| △ | 56-21 also 56-22 | 77-302 | | 80 Ni and 20 Cu. | |

TPRC



SPECIFIC HEAT -- NICKEL + COPPER

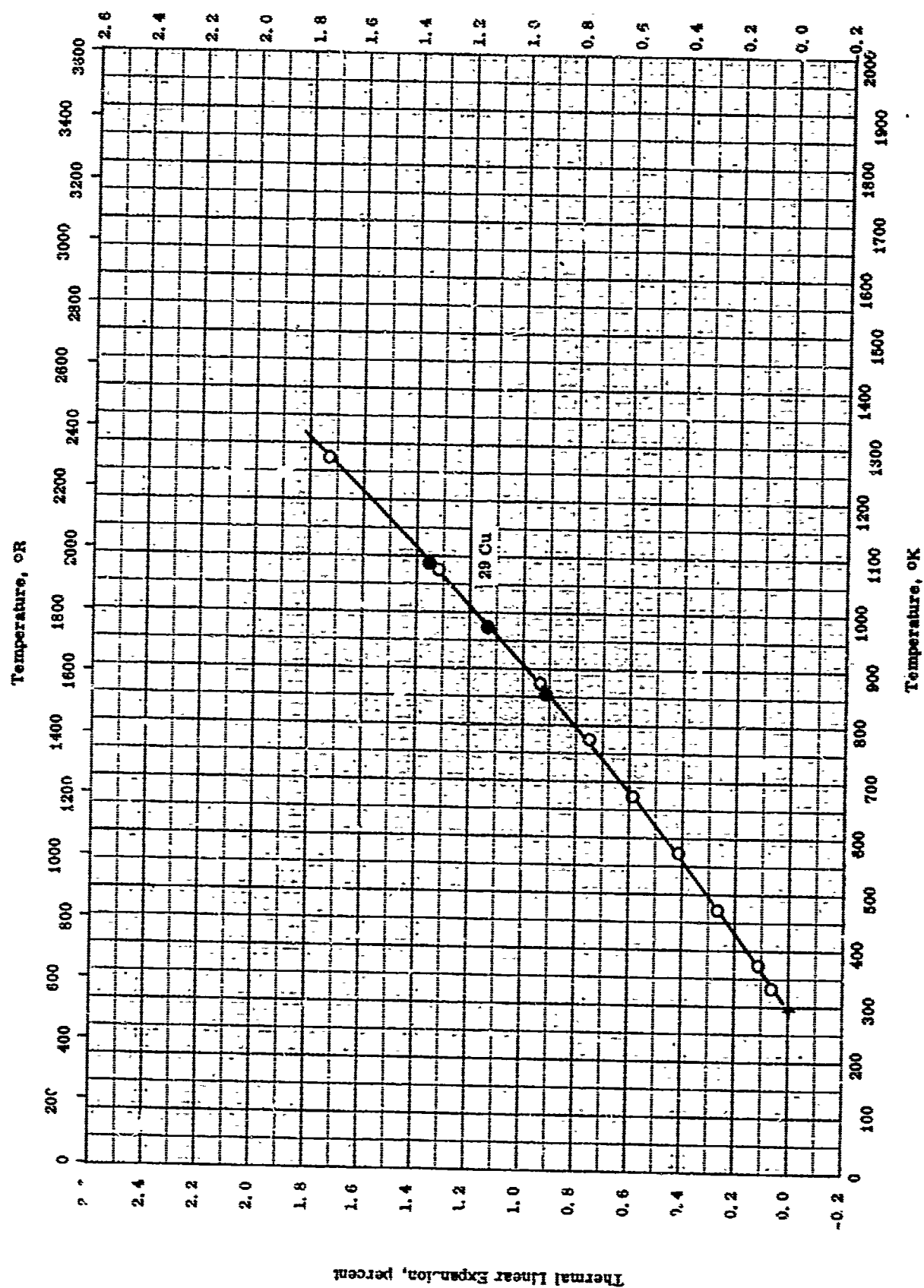
REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---------|
| ○ | 59-9 | 323-883 | ± 0.5 | 90% Nickel alloy; 90.05 Ni and 9.95 Cu. | |
| □ | 59-9 | 323-883 | ± 0.5 | 75% Nickel alloy; 75.07 Ni and 24.93 Cu. | |
| △ | 59-9 | 303-883 | ± 0.5 | 50% Nickel alloy; 50.04 Ni and 49.96 Cu. | |
| ◇ | 40-3 | 283-825 | ± 0.5 | 50 Ni and 50 Cu. | |

TPRC

Thermal Linear Expansion, percent

343



THERMAL LINEAR EXPANSION -- NICKEL + COPPER

TPRC

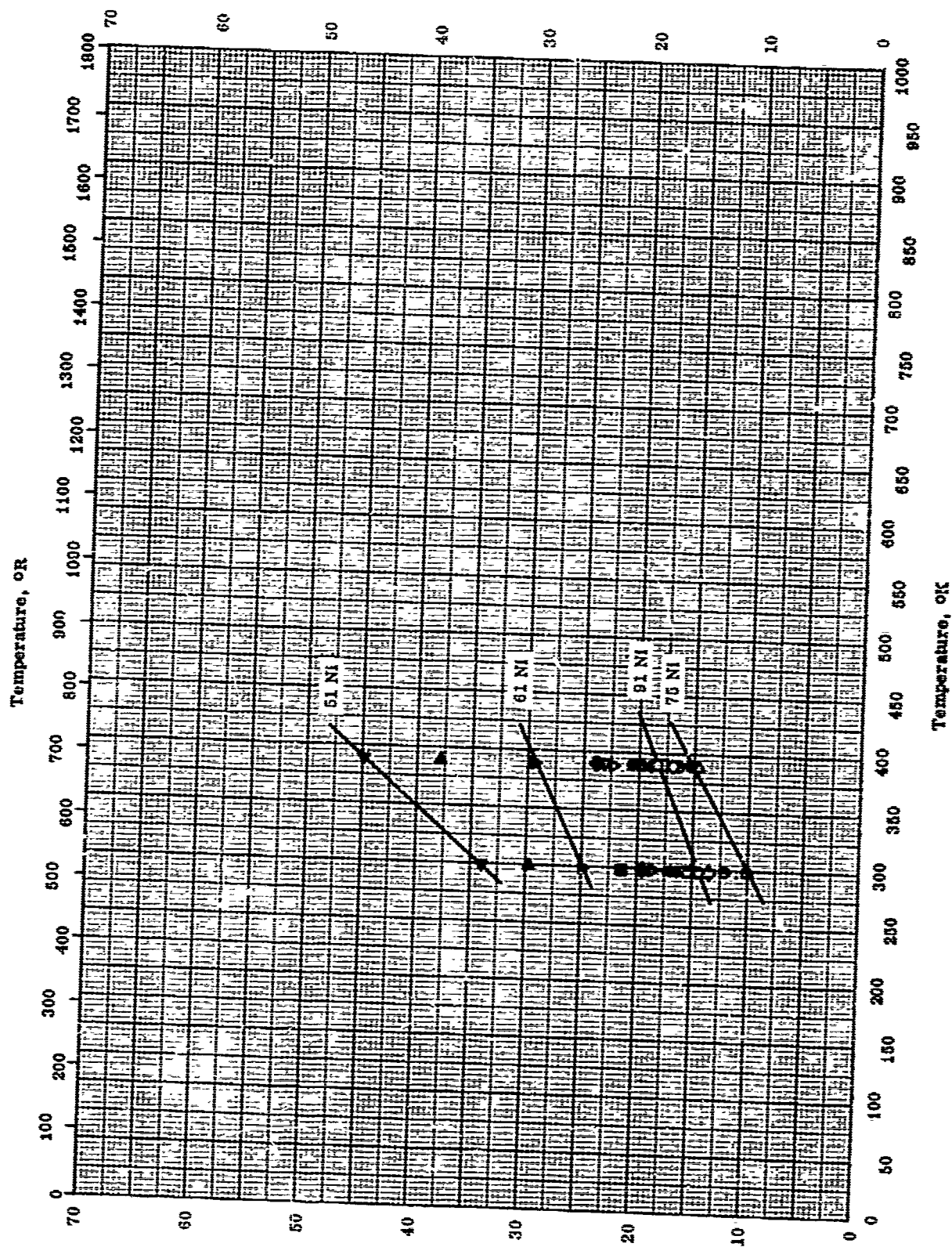
THERMAL LINEAR EXPANSION -- NICKEL + COPPER

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------------|--|
| ○ | 57-52 | 293-1273 | | Monel; 66.4 Ni and 29.4 Cu. | Annealed 3 hrs at 1000 C in pure dry hydrogen furnace, cooled 150 C hr ⁻¹ from 1000 to 800 C, then at 85 C hr ⁻¹ to 20 C; heating. |
| ● | 57-52 | 853-1273 | | Same as above. | Cooling data of above specimen. |

Electrical Resistivity, ohm cm x 10⁶

345



ELECTRICAL RESISTIVITY -- NICKEL + IRON

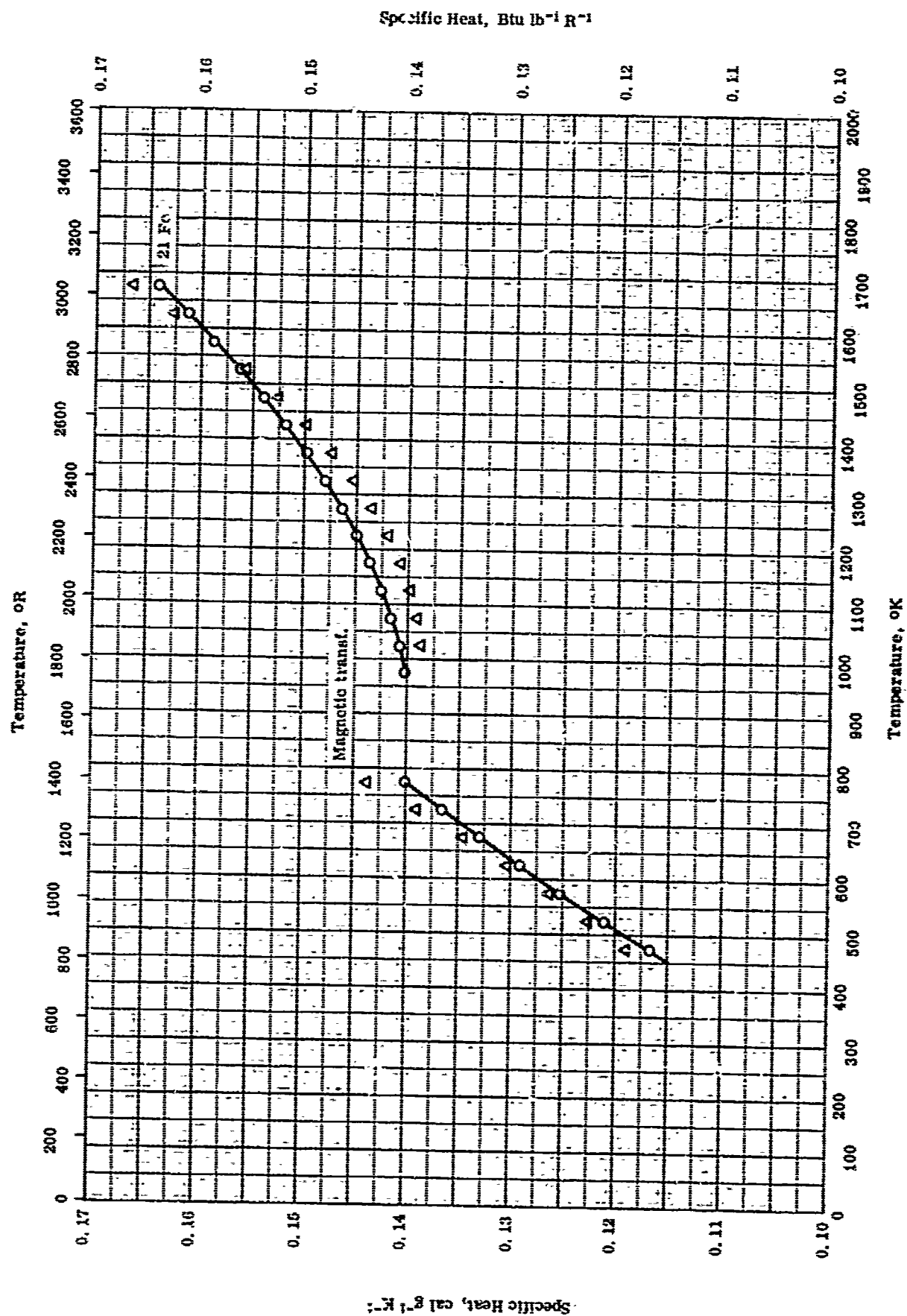
Electrical Resistivity, ohm cm x 10⁶

TPRC

ELECTRICAL RESISTIVITY -- NICKEL + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 57-24 | 298-373 | | 01.39 Ni; prepared from electrolytic Fe and Ni with less than 0.01 C. | Slowly cooled 1200 hrs from 450 C to 400 C; data for samples quenched from 500 C also reported. |
| □ | 57-24 | 298-373 | | 84.02 Ni; same as above. | Same as above. |
| △ | 57-24 | 298-373 | | 81.32 Ni; same as above. | Same as above. |
| ◇ | 57-24 | 298-373 | | 80.04 Ni; same as above. | Same as above. |
| ▽ | 57-24 | 298-373 | | 80.22 Ni; same as above. | Same as above. |
| △ | 57-24 | 298-373 | | 79.13 Ni; same as above. | Same as above. |
| ▽ | 57-24 | 298-373 | | 77.27 Ni; same as above. | Same as above. |
| ● | 57-24 | 298-373 | | 76.11 Ni; same as above. | Same as above. |
| ● | 57-24 | 298-373 | | 75.90 Ni; same as above. | Same as above. |
| ● | 57-24 | 298-373 | | 74.18 Ni; same as above. | Same as above. |
| ■ | 57-24 | 298-373 | | 73.05 Ni; same as above. | Same as above. |
| ▲ | 57-24 | 298-373 | | 71.21 Ni; same as above. | Same as above. |
| ◆ | 57-24 | 298-373 | | 66.43 Ni; same as above. | Same as above. |
| ▼ | 57-24 | 298-373 | | 61.18 Ni; same as above. | Same as above. |
| ▲ | 57-24 | 298-373 | | 56.23 Ni; same as above. | Same as above. |
| ▼ | 57-24 | 298-373 | | 51.24 Ni; same as above. | Same as above. |



SPECIFIC HEAT -- NICKEL + IRON

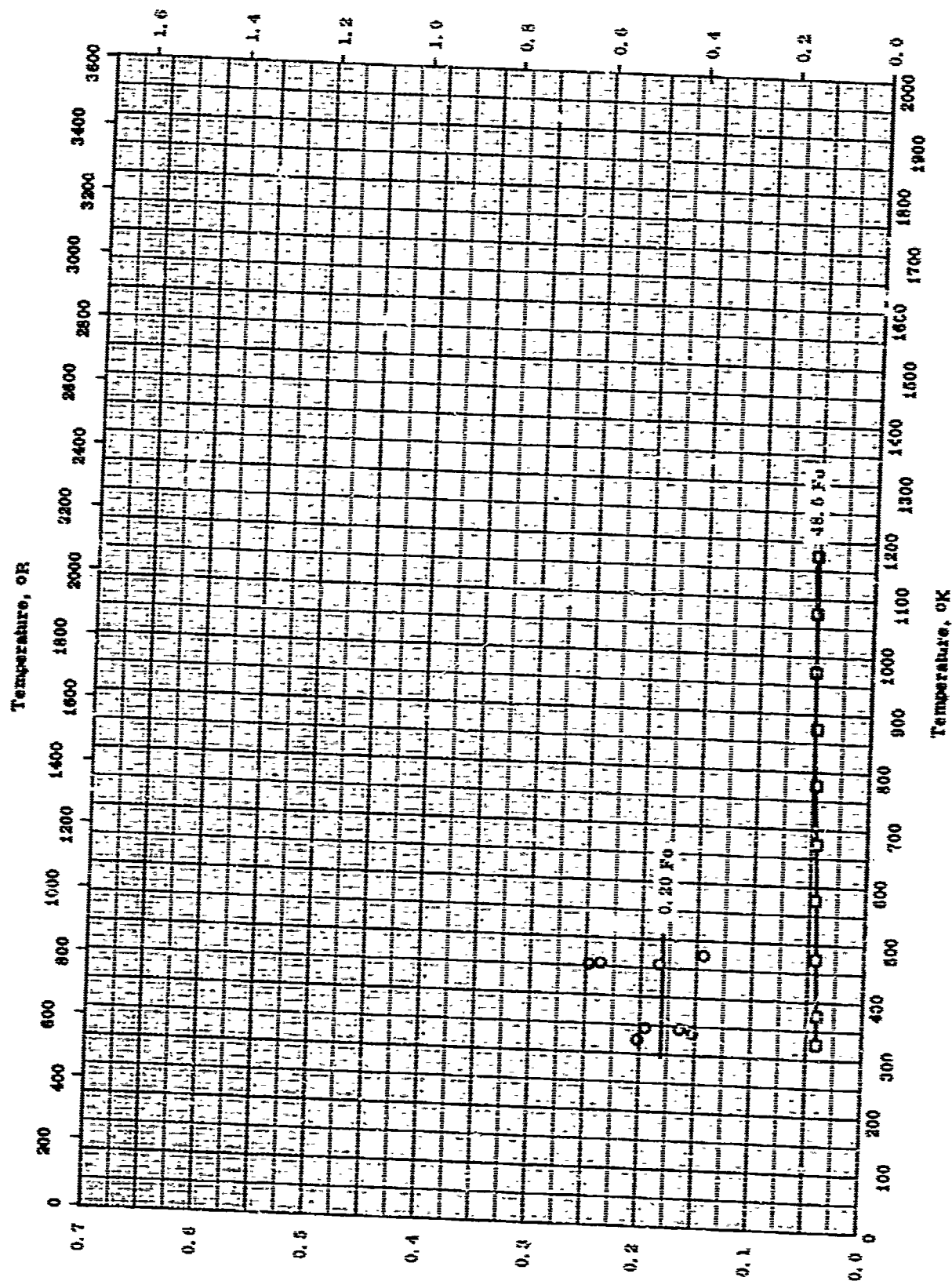
SPECIFIC HEAT -- NICKEL + IRON

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|------------------------|---------|
| O | 40-2 | 473-1673 | | 79.3 Ni and 20.7 Fe. | |
| Δ | 40-2 | 473-1673 | | 69.76 Ni and 30.24 Fe. | |

Thermal Conductivity, Btu hr⁻¹ ft⁻¹ R⁻¹ x 10⁻³

349



THERMAL CONDUCTIVITY -- NICKEL + IRON

TPRC

THERMAL CONDUCTIVITY -- NICKEL + IRON

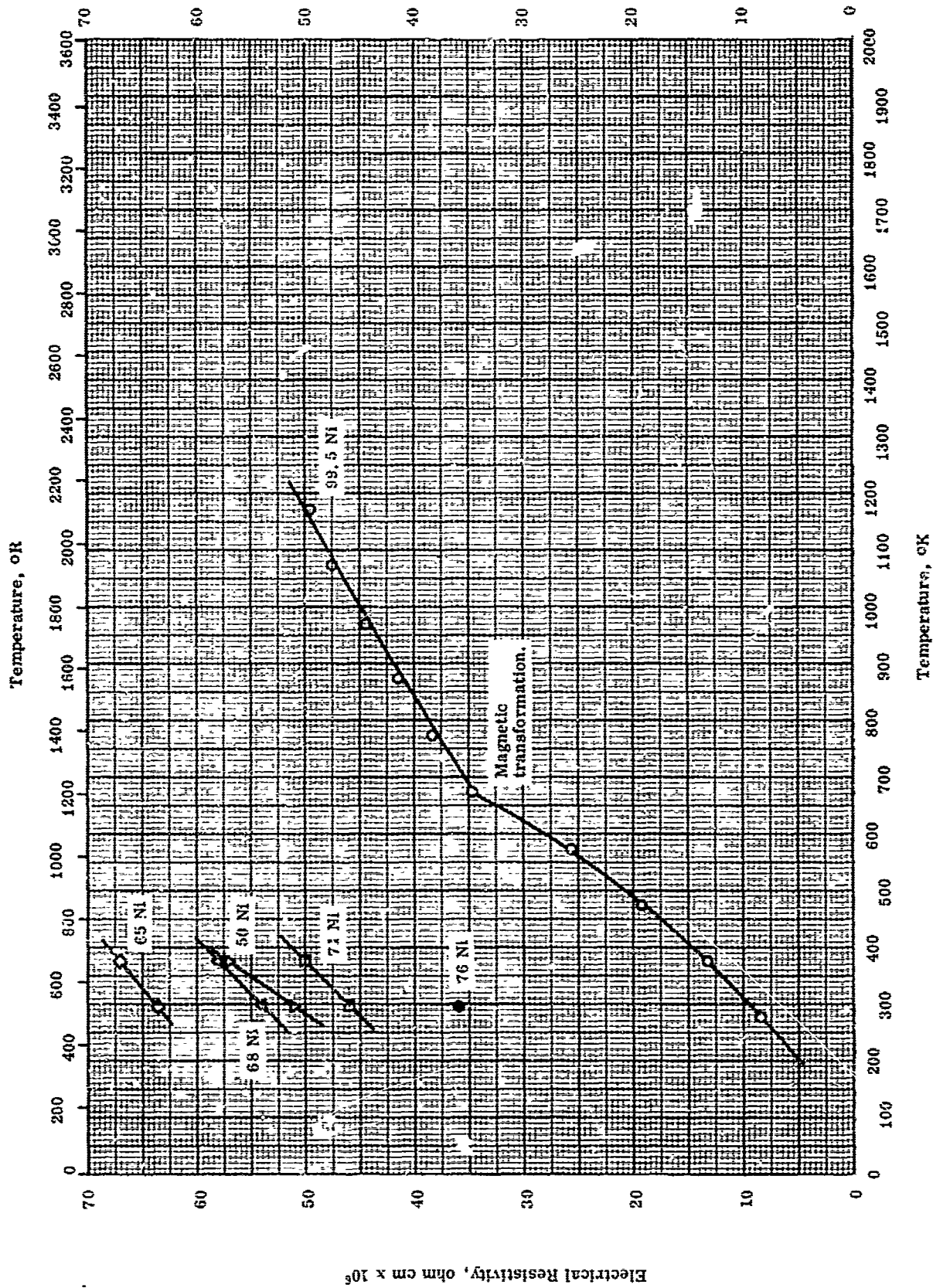
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---------|
| O | 53-6 | 328-472 | | Commercial Grade; 99.4 Ni, 0.20 Fe, 0.10 Mg, 0.05 Co, 0.03 Sn, 0.026 C, 0.02 Si, 0.01 Cr and Mn each, 0.005 S, 0.003 Ti, and 0.002 Al and Pb each. | |
| C | 53-2 | 323-1173 | | 50.85 Ni, 48.5 Fe, 0.12 Mn, 0.024 C, and 0.003 S. | |

TPRC

Electrical Resistivity, ohm cm x 10⁶

561



ELECTRICAL RESISTIVITY -- NICKEL + MANGANESE

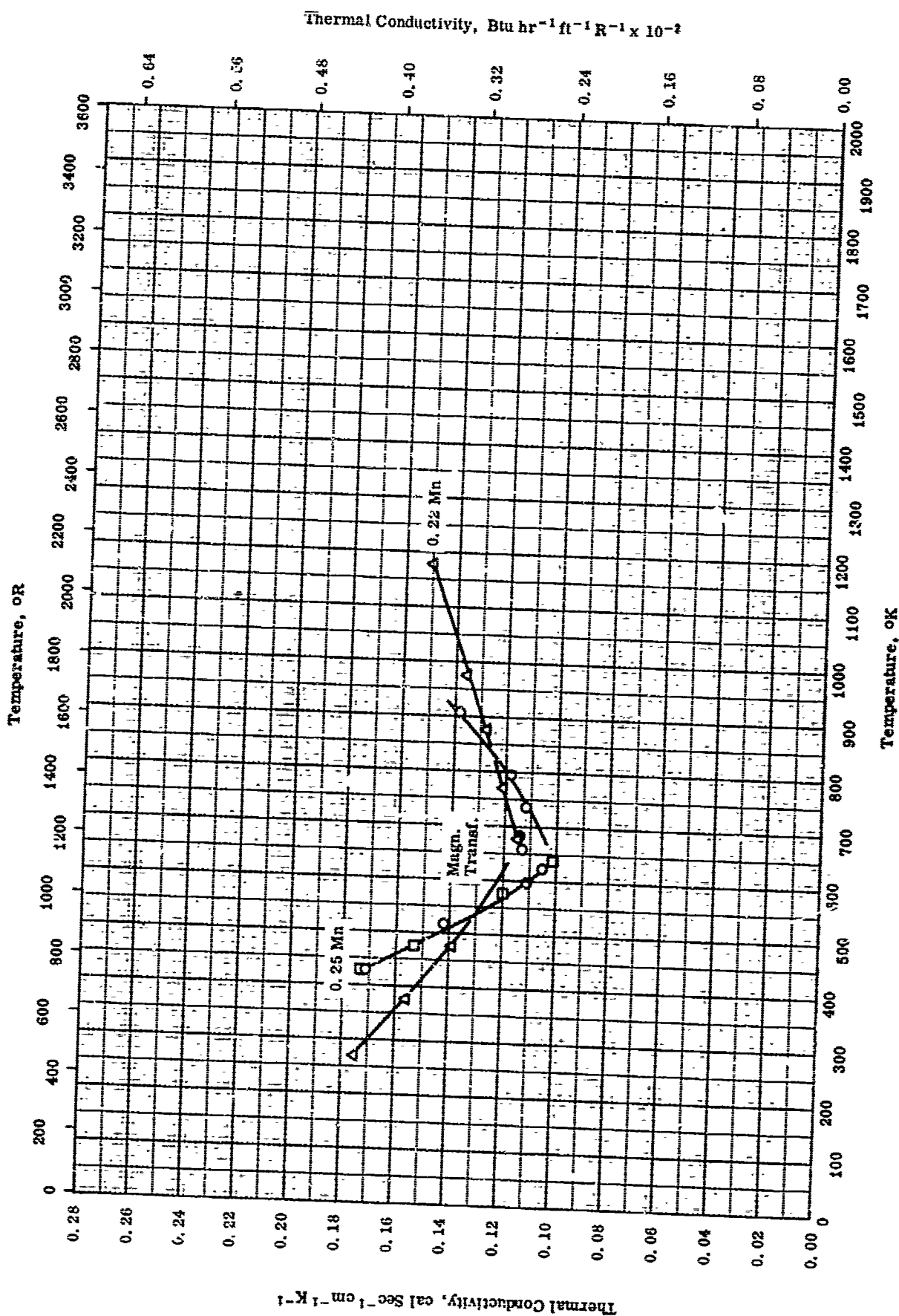
TPRC

ELECTRICAL RESISTIVITY -- NICKEL + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---|
| ● | 49-6 | 298-373 | | 75.89 Ni; made from electrolytic Mn and Ni in alumina crucibles in an induction furnace. | Annealed in steps from 980 C to 500 C, the entire process lasting 5 days. |
| □ | 49-6 | 298-373 | | 71.39 Ni. | Same as above. |
| △ | 49-6 | 298-373 | | 69.45 Ni. | Same as above. |
| ◇ | 49-6 | 298-373 | | 66.39 Ni. | Same as above. |
| ▽ | 49-6 | 298-373 | | 51.90 Ni. | Same as above. |
| ○ | 52-4 | 273-1173 | | 99.48 Ni, 0.22 Mn, 0.14 Fe, 0.06 C, 0.05 Cu, 0.02 Si, and 0.005 S. | |

TPRC



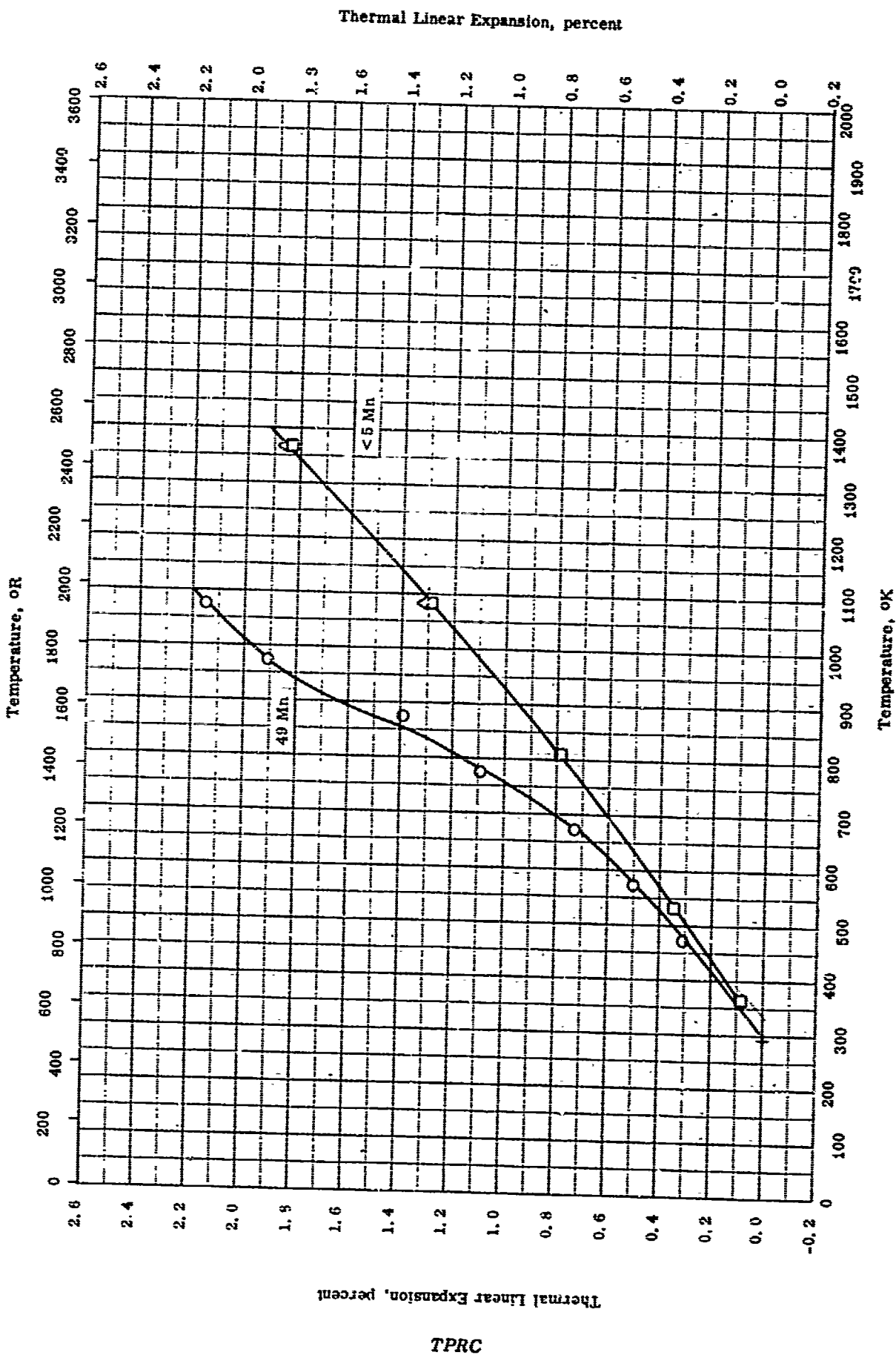
THERMAL CONDUCTIVITY --- NICKEL + MANGANESE

THERMAL CONDUCTIVITY -- NICKEL + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| ○ | 54-2 | 422-910 | | Grade A; 99.542 Ni, 0.250 Mn, 0.068 Fe, 0.034 Co, 0.034 Mg, 0.030 Si, 0.020 Ti, 0.014 Cu, 0.006 Al, 0.001 B, 0.0005 Ca, and 0.0005 Cr. | In rod form; measured in vacuum of 2×10^{-4} mm Hg. |
| □ | 57-4 | 423-643 | | Grade A; 99.54 Ni, 0.25 Mn, 0.07 Fe, 0.03 Co, Mg, and Si each, and traces of others. | In rod form; measured in vacuum. |
| △ | 52-4 | 273-1173 | | 99.46 Ni, 0.22 Mn, 6.14 Fe, 0.06 C, 0.05 Cu, 0.02 Si, and 0.005 S. | |

TPRC



Thermal Linear Expansion -- NICKEL + MANGANESE

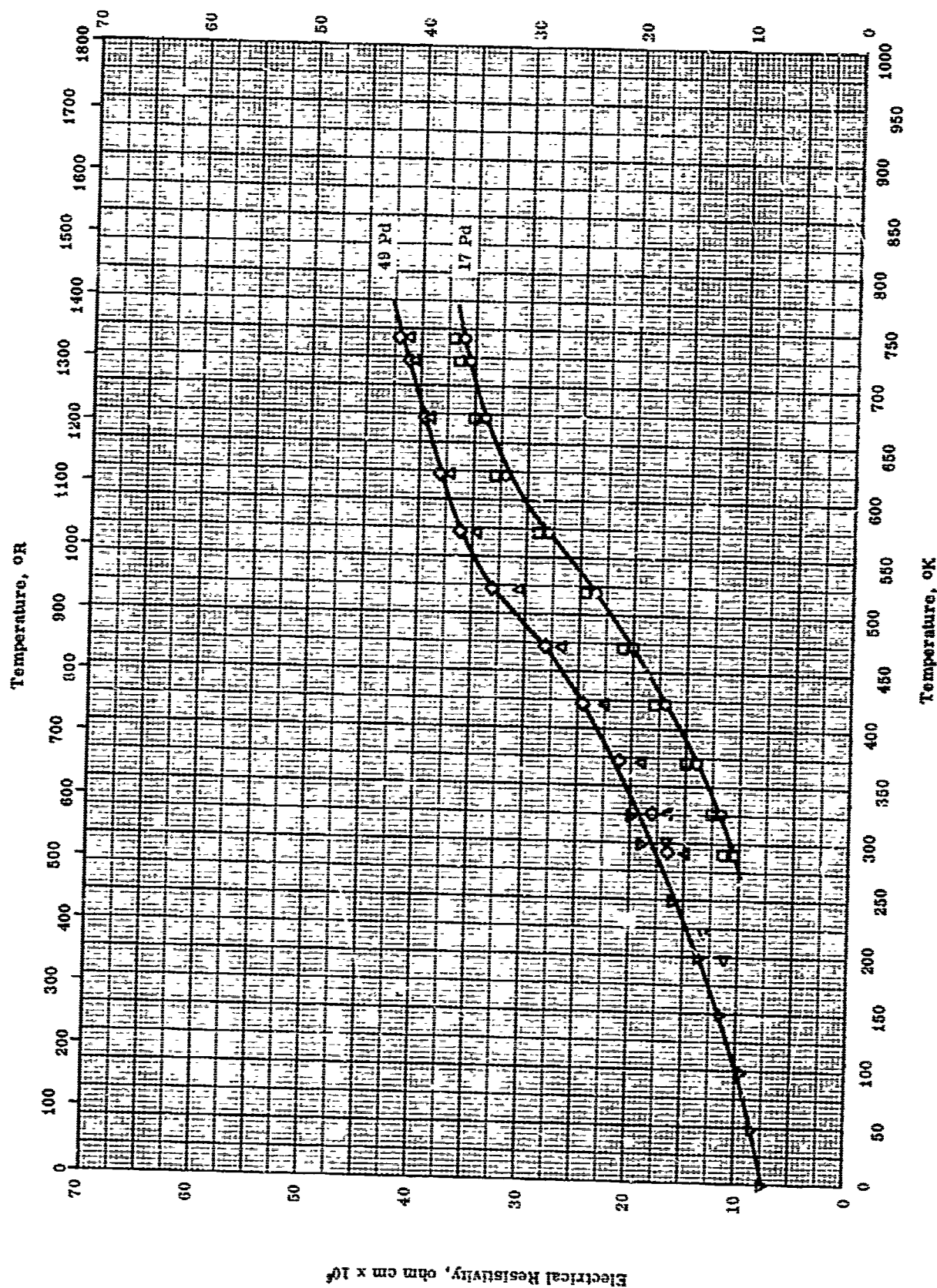
THERMAL LINEAR EXPANSION -- NICKEL + MANGANESE

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rupt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---------------------------|
| ○ | 55-38 | 283-1073 | | 50.6 Ni and 49.4 Mn; prepared from electrolytic purity metals. | Quenched and homogenized. |
| □ | 65-4 | 294-1367 | | Nickel 200; formally "A-Nickel" from International Nickel Co.; nominal: 99.5 Ni, 0.25 Mn, 0.15 Fe, 0.06 C, 0.05 Si, 0.05 Cu and 0.005 S; density 0.321 lb in. ⁻³ and M.P. 2615 - 2635 F. | |
| △ | 65-4 | 294-1367 | | Nickel 211; formall "D-Nickel" from International Nickel Co.; nominal: 95.0 Ni, 4.75 Mn, 0.10 C, 0.05 Fe, 0.05 Si, 0.03 Cu, and 0.005 S; density 0.315 lb in. ⁻³ . | |

Electrical Resistivity, ohm cm $\times 10^6$

357



ELECTRICAL RESISTIVITY -- NICKEL + PALLADIUM

TYRC

ELECTRICAL RESISTIVITY -- NICKEL + PALLADIUM

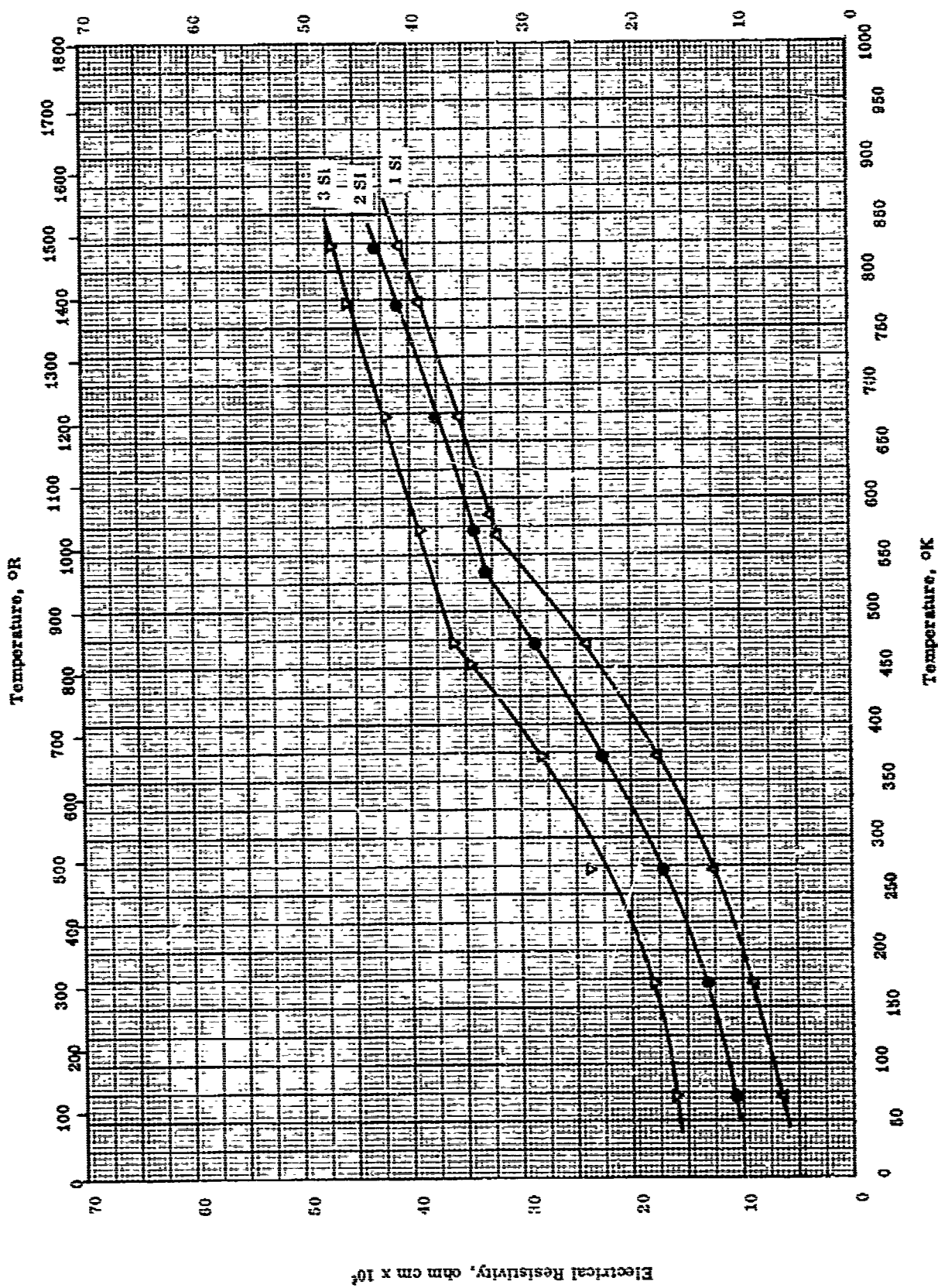
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|---|--|
| ○ | 57-20 also 57-21 | 293-743 | | 83.04 Ni and 16.96 Pd. | Annealed 2 hrs at 1070 K in vacuum, furnace cooled 24 hrs; tested in vacuum. |
| □ | 57-20 also 57-21 | 293-743 | | 81.04 Ni and 18.96 Pd. | Same as above. |
| △ | 57-20 also 57-21 | 293-743 | | 60.77 Ni and 39.23 Pd. | Same as above. |
| ◇ | 57-20 also 57-21 | 293-743 | | 51.08 Ni and 48.92 Pd. | Same as above. |
| ▽ | 56-19 | 0-325 | | 60.77 Ni and 39.23 Pd. | Annealed 2 hrs at 1070 K in vacuum, furnace cooled 24 hrs. |
| ◁ | 56-19 | 200-325 | | Two samples: a. 61 Ni and 39 Pd b. 50.2 Ni and 49.8 Pd. | Same as above. |

TPRC

Electrical Resistivity, ohm cm $\times 10^4$

359



ELECTRICAL RESISTIVITY -- NICKEL + SILICON

TPRC

ELECTRICAL RESISTIVITY -- NICKEL + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|--|
| △ | 55-0 | 73-823 | | 1.0015 SI. | Alloy prepared from 99.9 pure Ni and 99.95 pure Si homogenized 6-10 hrs just below M.P. |
| ● | 55-0 | 73-823 | | 1.99 SI. | Same as above. |
| ▽ | 55-0 | 73-823 | | 3.00 SI. | Same as above. |

TPRC

PROPERTIES OF NIOBIUM - TANTALUM

REPORTED VALUES

| Melting Point: | K | R |
|----------------|---------------|---------------|
| ○ 1.9 Ta | 2741 ± 10 | 4934 ± 15 |
| ◇ 0.5 Ta | 2708 | 4575 |

TPRC

PROPERTIES OF NIOBIUM + TANTALUM

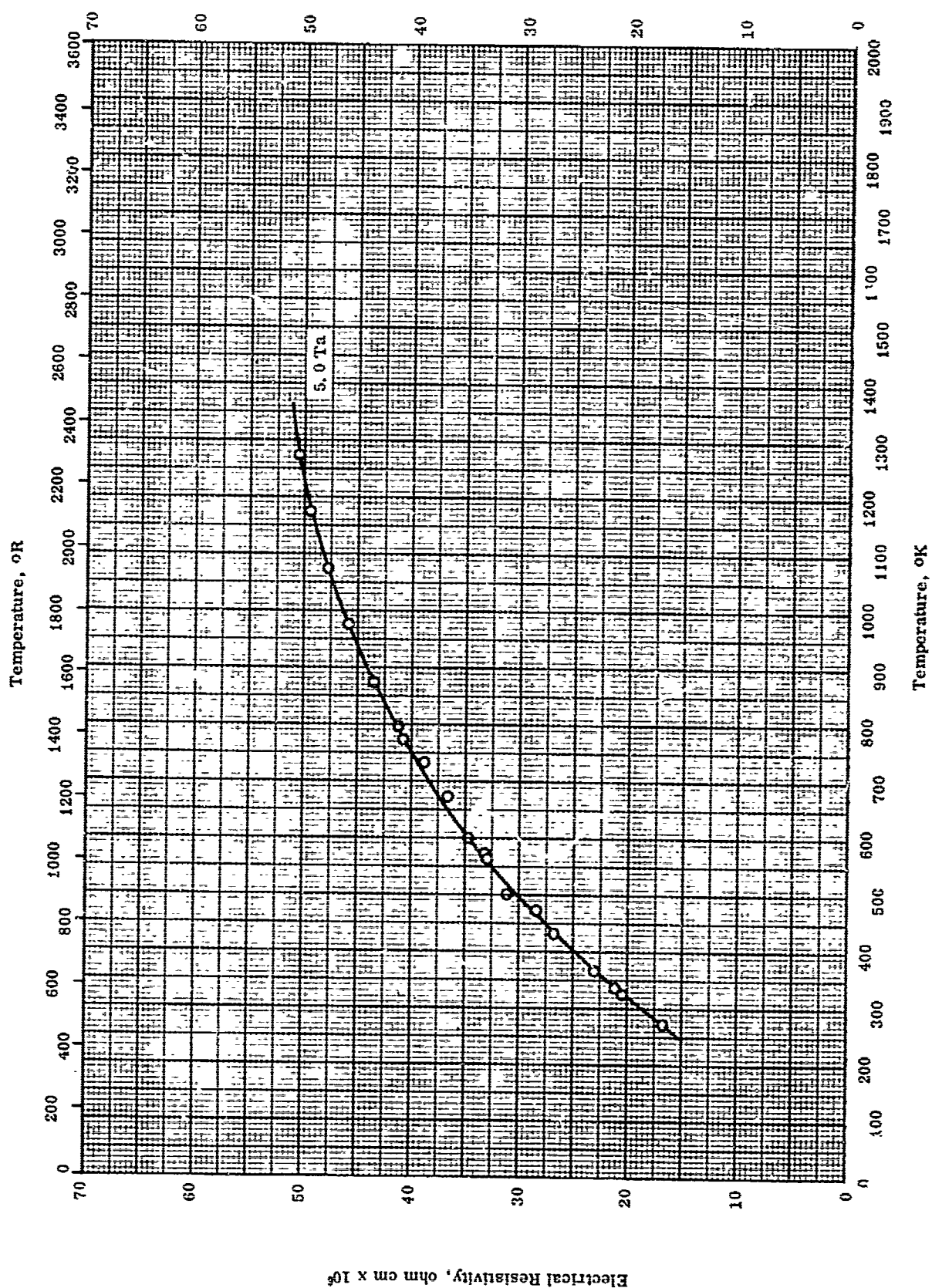
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|--|---|
| ○ | 57-82 | 2731-2751 | ± 10C | 1.9 ± 0.1 Ta, 0.0032 gas content, 0.0025 N ₂ , and 0.00013 H ₂ . | M. P. by liquid forming in black body cavity of sample. |
| ◇ | 54-24 also 55-30 | 2708 | | 0.5 Ta, 0.25 C, 0.05 Fe, 0.05 Si, and 0.05 Ti. | |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$

363



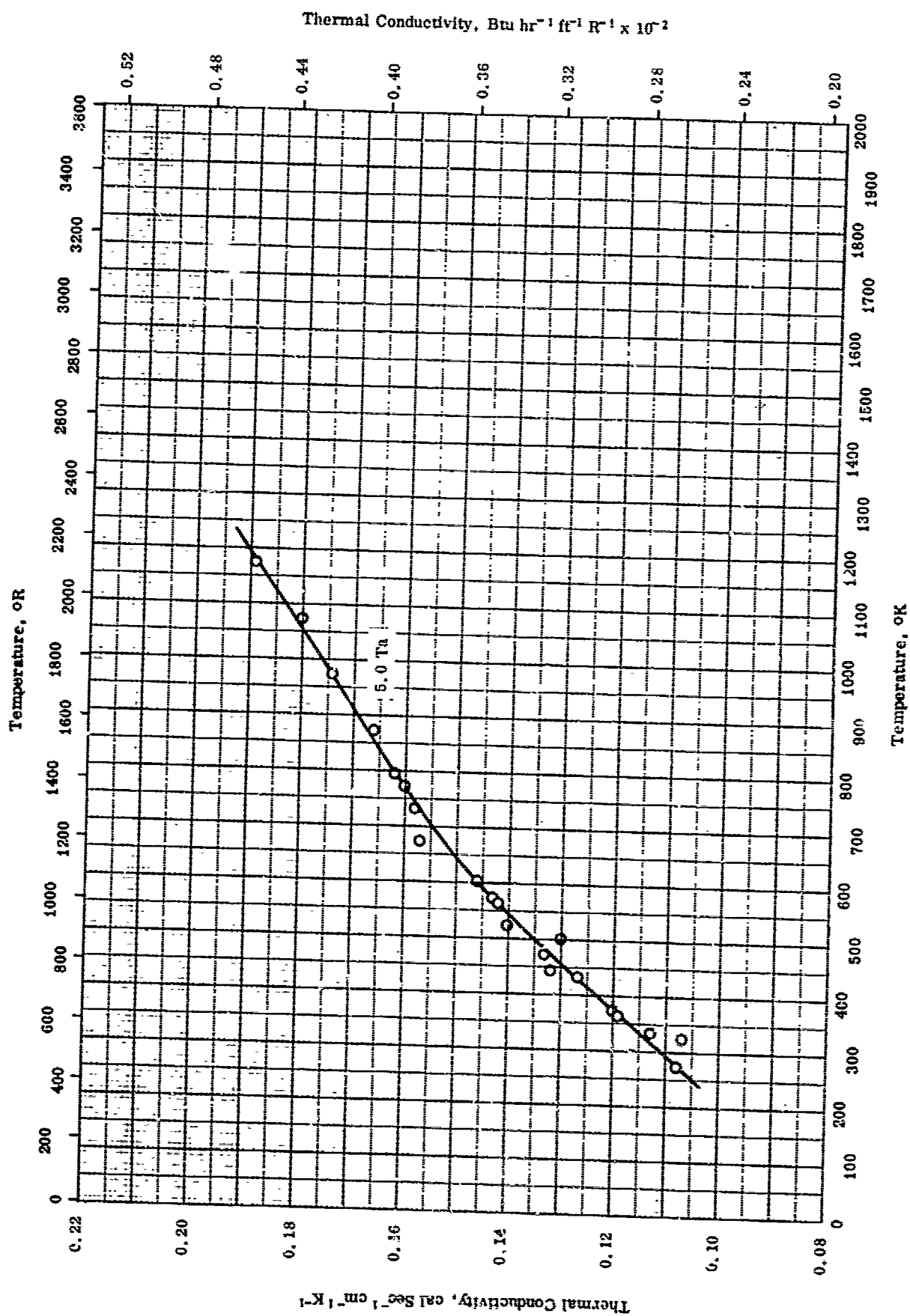
ELECTRICAL RESISTIVITY -- NIObIUM + TANTALUM

TPRC

ELECTRICAL RESISTIVITY -- NIOBIUM + TANTALUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| O | 63-10 | 273-1273 | | 5.0 Ta, 0.17 W, 0.064 Fe, 0.04 Mo, 0.014 Ti, 0.014 Si, and 0.013 C. | Sintered in vacuum at 1373 F for 5 hrs, residual pressure in the furnace 10^{-3} mm Hg; finally sintered in a vacuum of 10^{-6} mm Hg at 2623 K for 5 hrs; refined twice by zone-melting. |



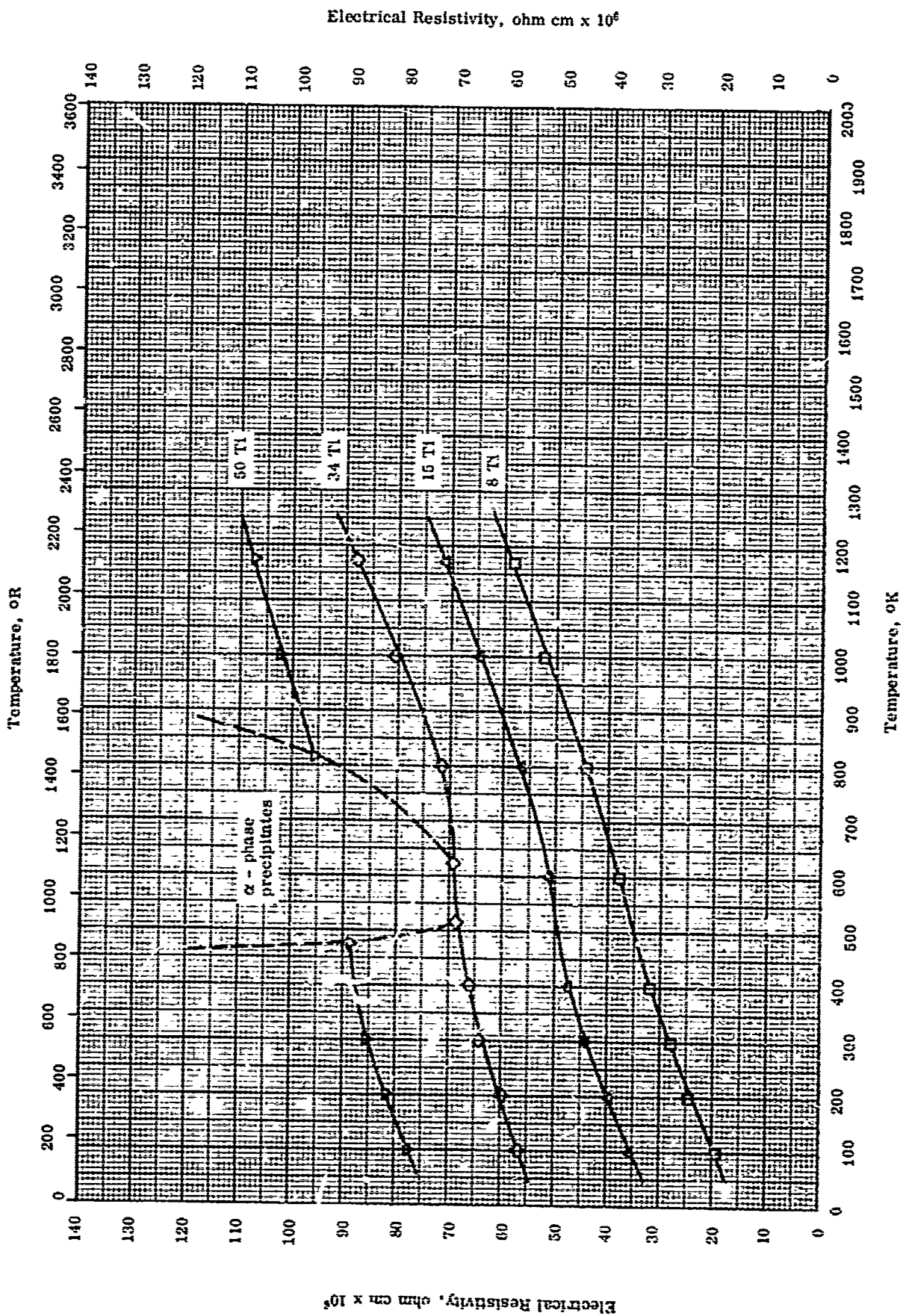
THERMAL CONDUCTIVITY -- NIOBIUM + TANTALUM

THERMAL CONDUCTIVITY -- NIOBIUM + TANTALUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|-------|--------------------|-------------------|--|--|
| O | 63-10 | 273-1173 | | 5.0 Ta, 0.17 W, 0.054 Fe, 0.04 Mo, 0.014 Ti, 0.014 Si, and 0.013 C; prepared from electrolytic powders. | Pressed by 3.5 ton in ² and double sintered at 1373 K and 2023 K in vacuum; forged and twice zone melted. |

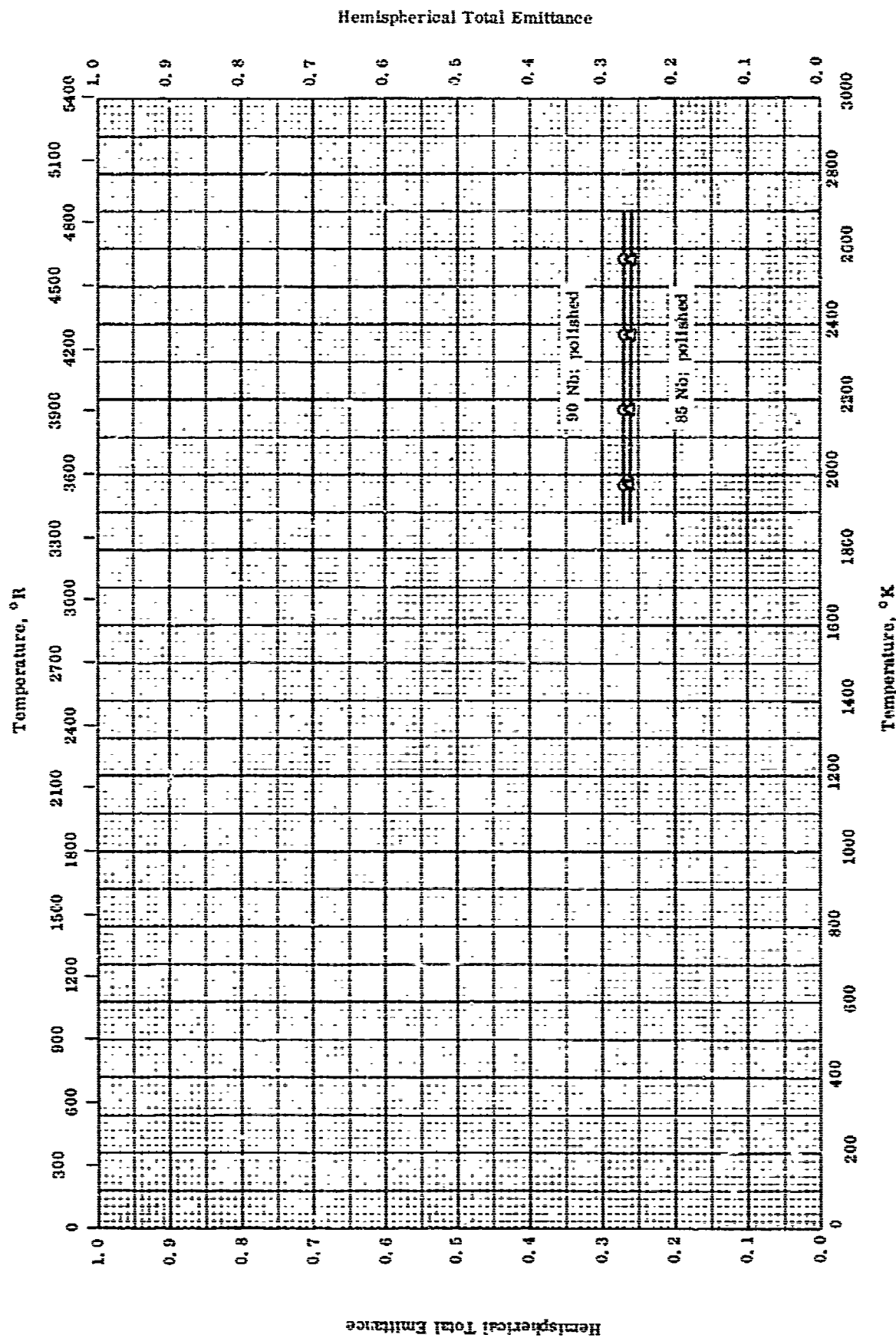
TPRC



ELECTRICAL RESISTIVITY -- NIOBIUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| □ | 54-16 | 100-1173 | | 91.7 Nb and 8.3 Ti; β - phase; prepared from spectroscopically pure Nb and iodide Ti (0.2 atomic % Zr) | Cast; rolled in sheet, recrystallized, hot forged, surface layer removed, cold swaged, homogenized 70 hrs at 105° C in vacuum, and then quenched to retain β phase. |
| △ | 54-16 | 100-1173 | | 84.7 Nb and 15.3 Ti; β - phase; raw materials same as above. | Same as above. |
| ◇ | 54-16 | 100-1173 | | 66 Nb and 34 Ti; β - phase; raw materials same as above. | Same as above. |
| ▽ | 54-16 | 100-1173 | | 50 Nb and 50 Ti; β - phase; raw materials same as above. | Same as above. |

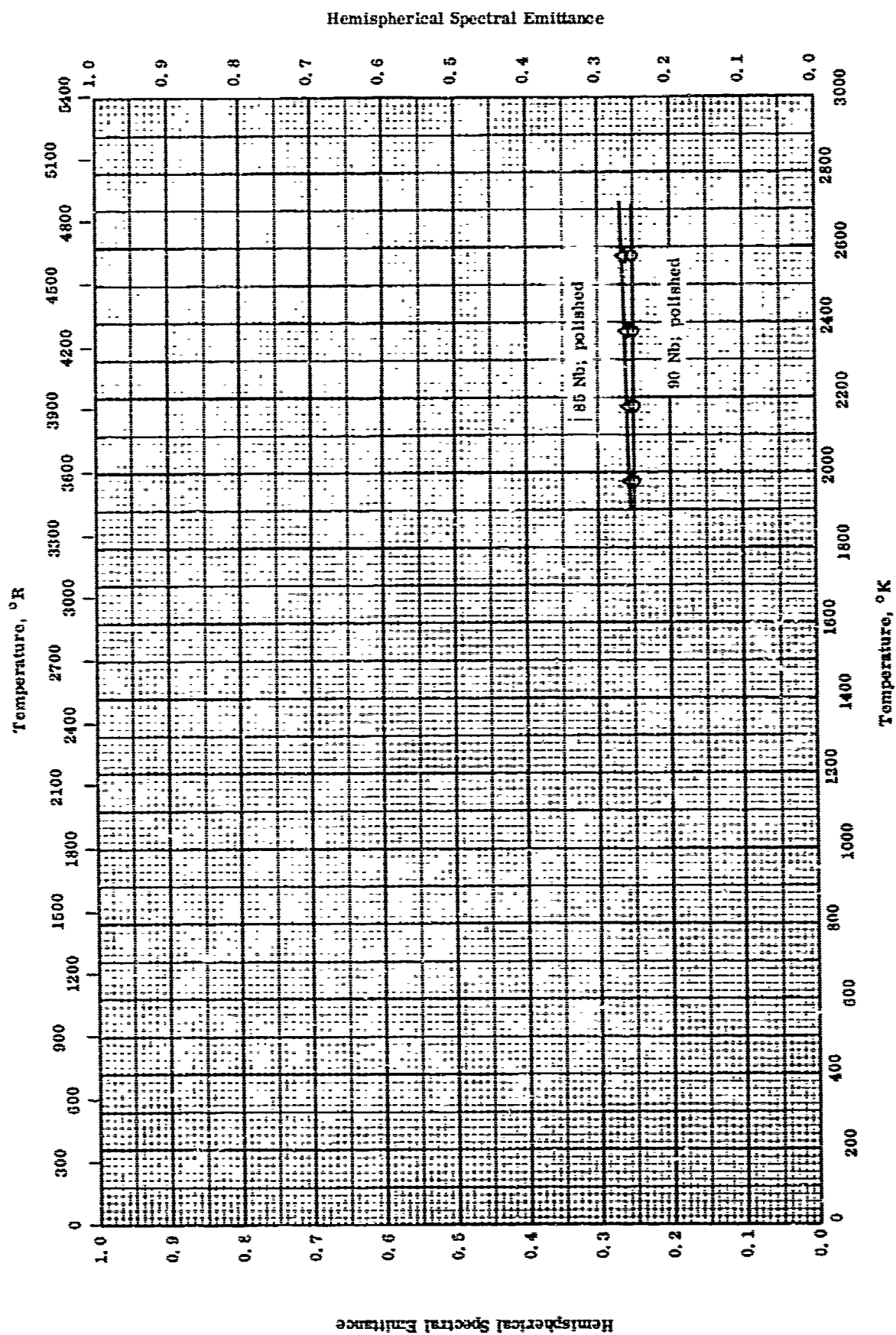


HEMISPHERICAL TOTAL EMITTANCE --- NIOBIUM + TUNGSTEN

HEMISPHERICAL TOTAL EMITTANCE -- NIOBIUM + TUNGSTEN

REFERENCE INFORMATION

| Sym | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----|-------|-------------------|------------------|-----------------------|---|
| ○ | 62-20 | 1973-2573 | | 90 Nb and 10 W. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000); measured in argon. |
| △ | 62-20 | 1973-2573 | | 85 Nb and 15 W. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000); measured in argon. |

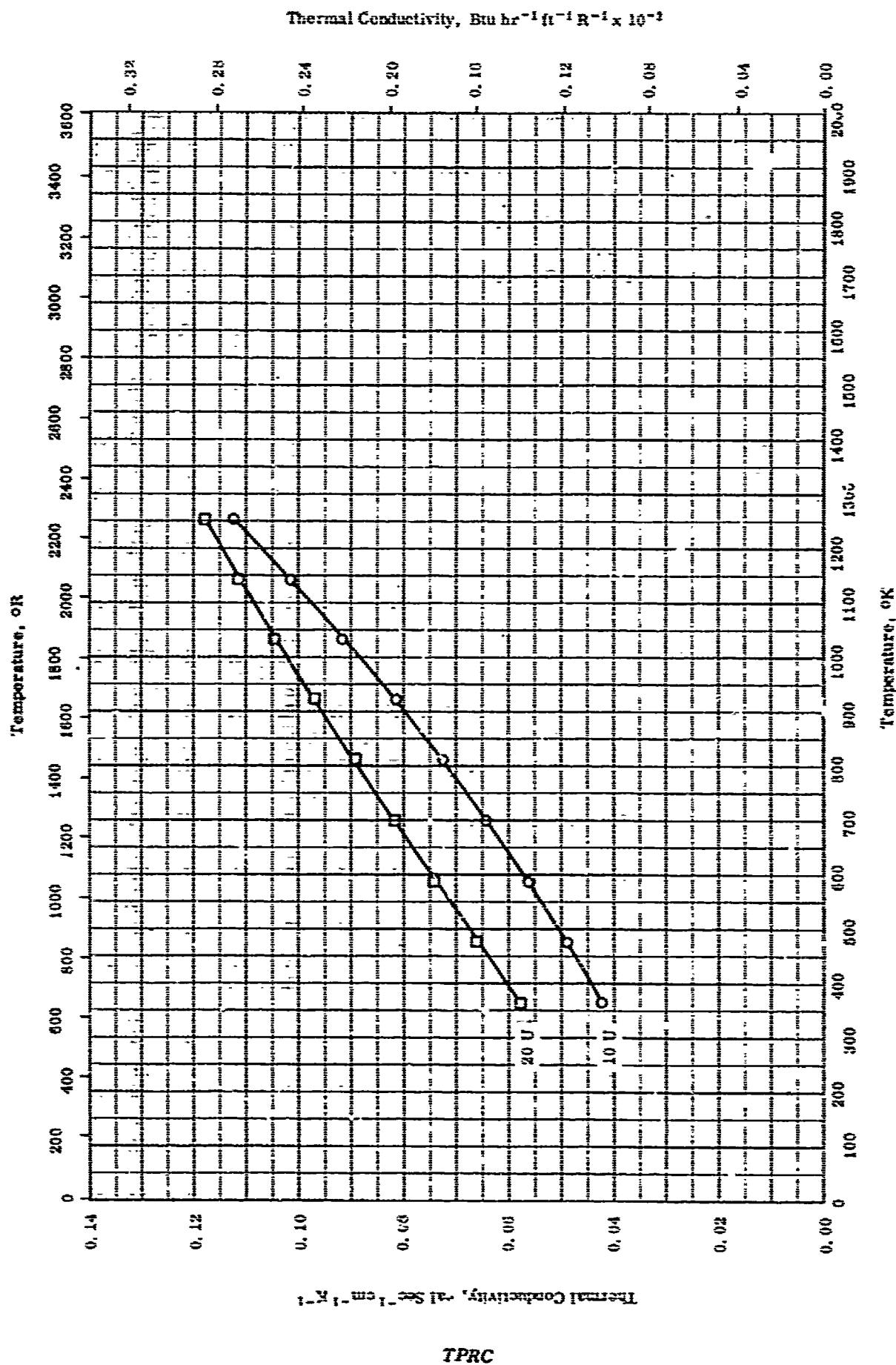


HEMISPHERICAL SPECTRAL EMITTANCE -- NIOBIUM + TUNGSTEN

HEMISPHERICAL SPECTRAL EMITTANCE -- NIOBIUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. °K Range | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|---------------------|-------------------|------------------|-----------------------|---|
| ○ | 02-20 | 0.05 | 1973-2573 | | 90 Nb and 10 W. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000) ; measured in argon. |
| △ | 02-20 | 0.05 | 1973-2573 | | 85 Nb and 15 W. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000) ; measured in argon. |

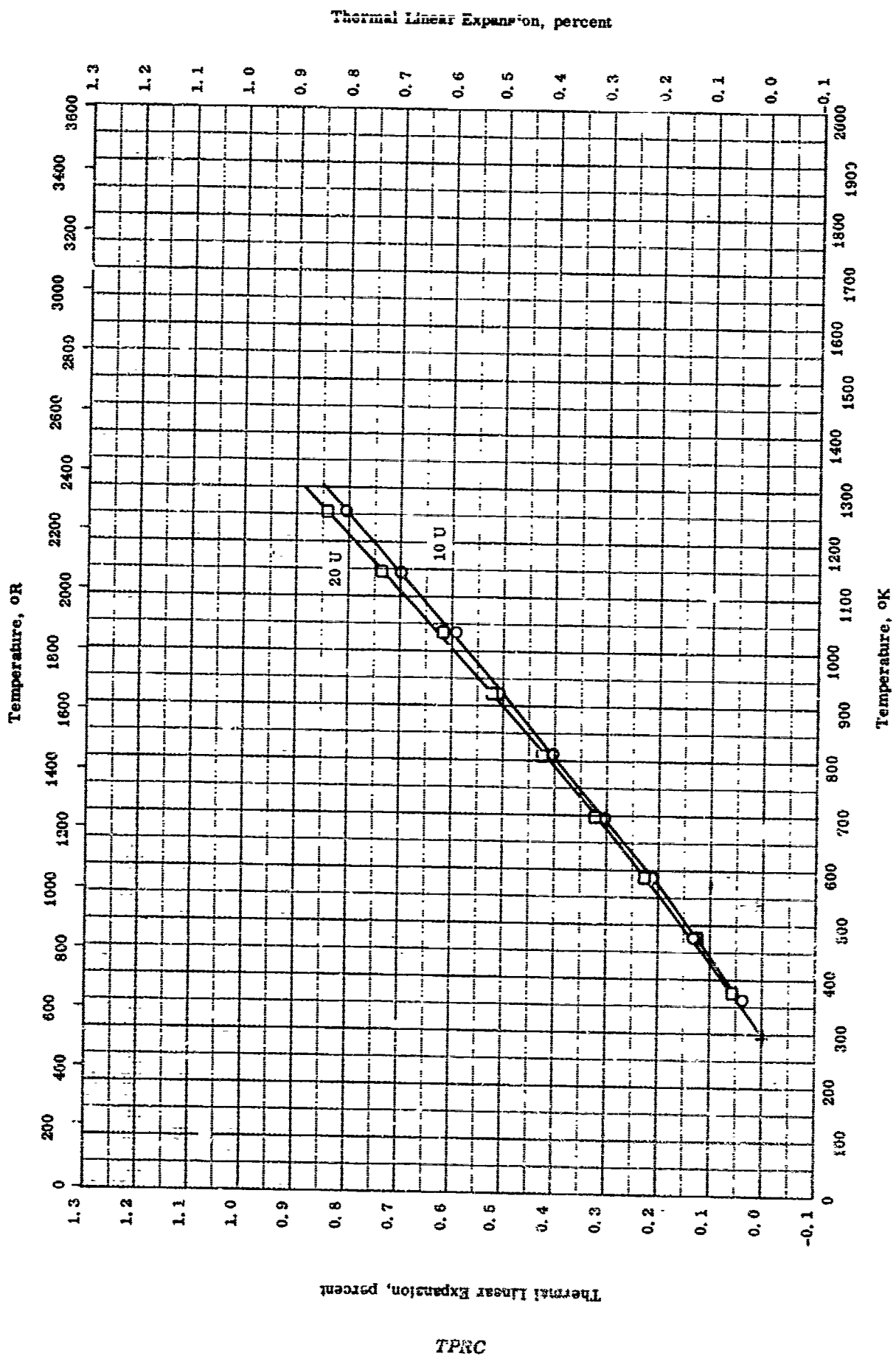


THERMAL CONDUCTIVITY -- NIOBIUM + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|--|
| ○ | 61-3 | 367-1255 | | 90 Nb and 10 U. | Measured in a vacuum of approx 2×10^{-5} mm Hg. Same as above. |
| □ | 61-3 | 367-1255 | | 80 Nb and 20 U. | |

TPRC



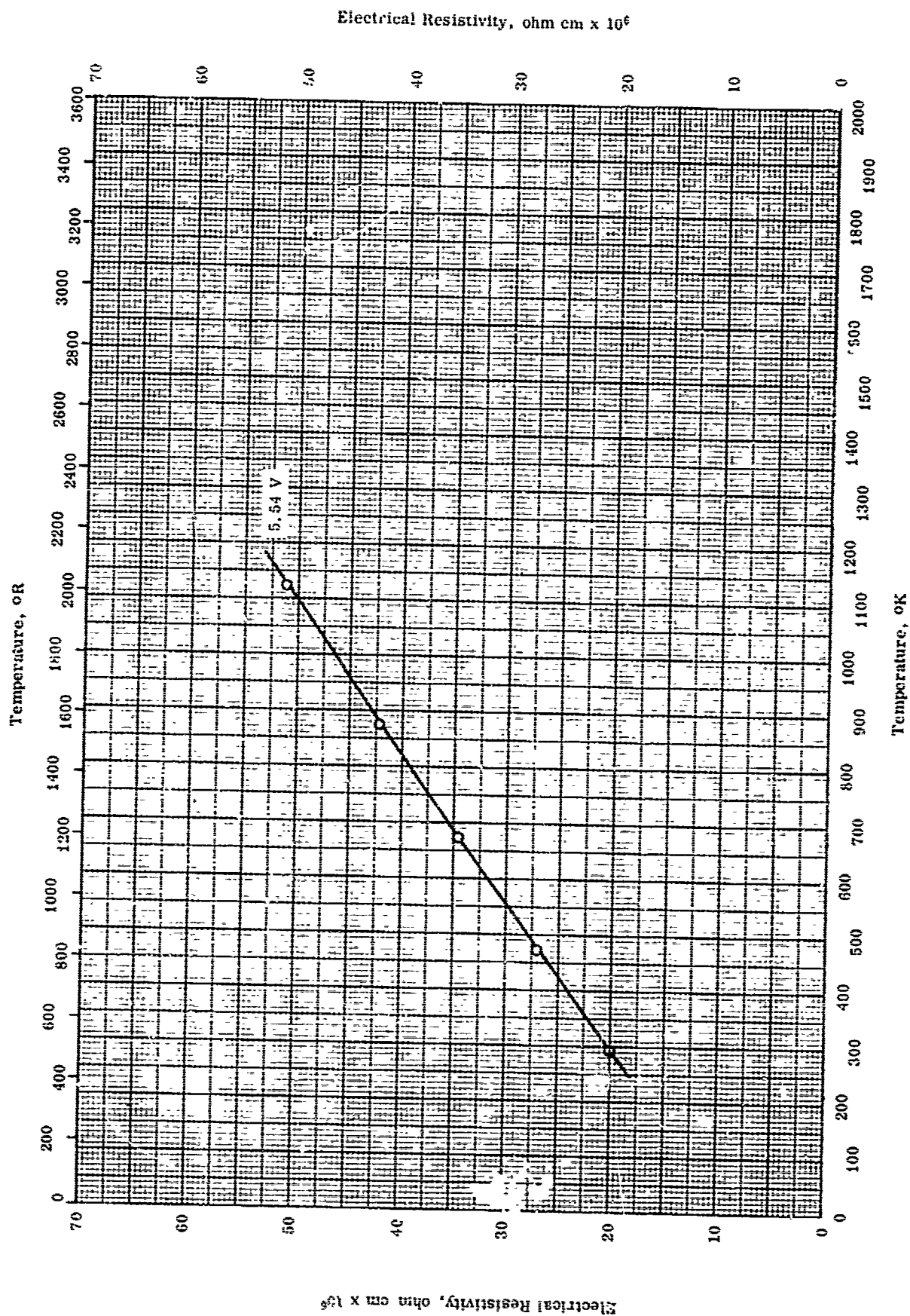
THERMAL LINEAR EXPANSION -- NIOBIUM + URANIUM

THERMAL LINEAR EXPANSION -- NIOBIUM + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|--|
| ○ | 61-3 | 293-1255 | | 90 Nb and 10 U. | Thermal cycled twice from room temperature to about 1800 F and back to room temperature; measured in vacuum of at least 5×10^{-5} mm Hg. Same as above specimen. |
| □ | 61-3 | 293-1255 | | 80 Nb and 20 U. | |

TPRC



377

ELECTRICAL RESISTIVITY -- NIOBIUM + VANADIUM

TPRC

ELECTRICAL RESISTIVITY -- NIOBIUM + VANADIUM

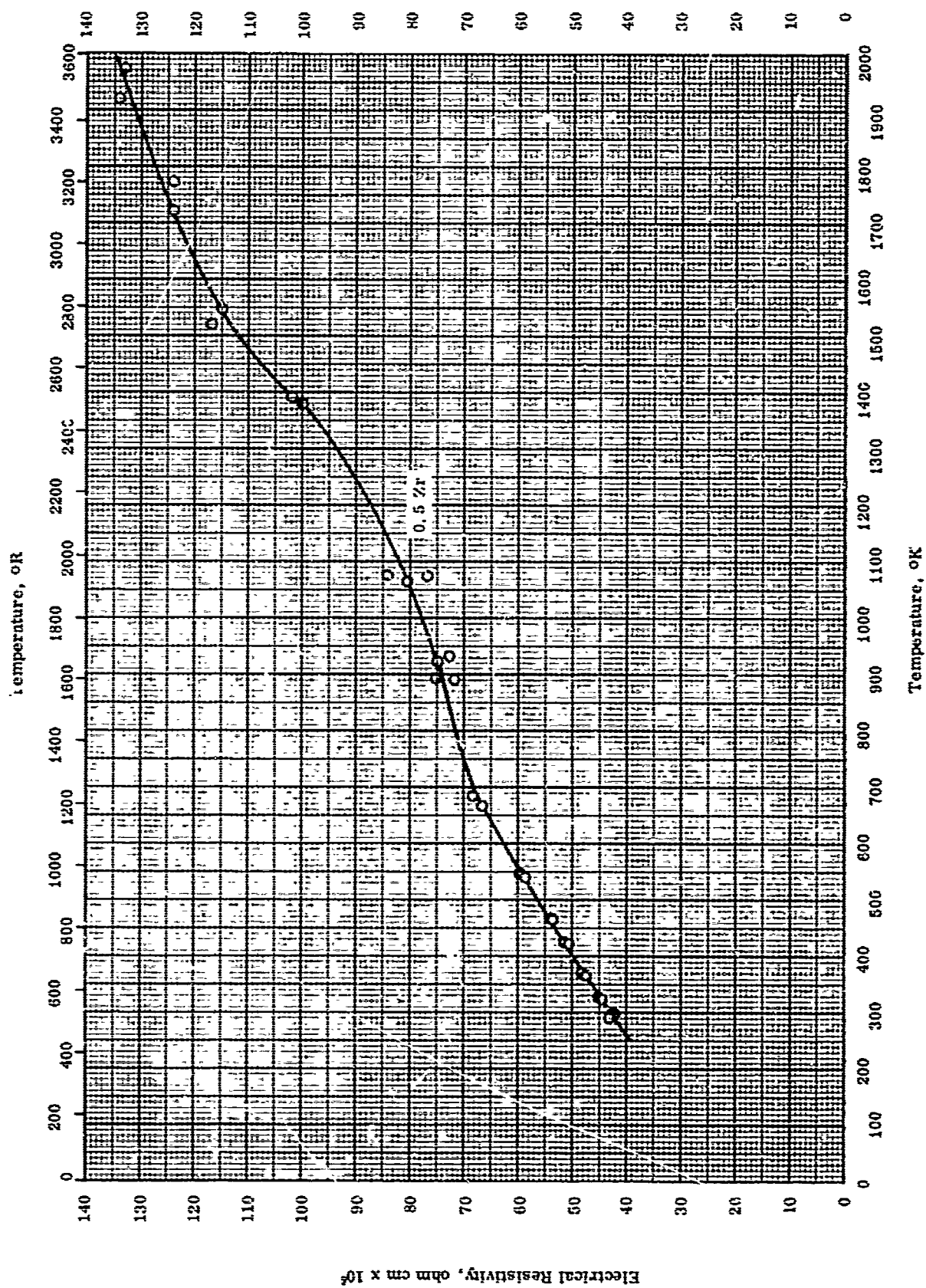
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| O | 61-21 | 203-1123 | | 5.54 V, 0.052 T _A , 0.0160 N, 0.0142 O, and 0.0065 C. | |

TPRC

Electrical Resistivity, ohm cm $\times 10^5$

379



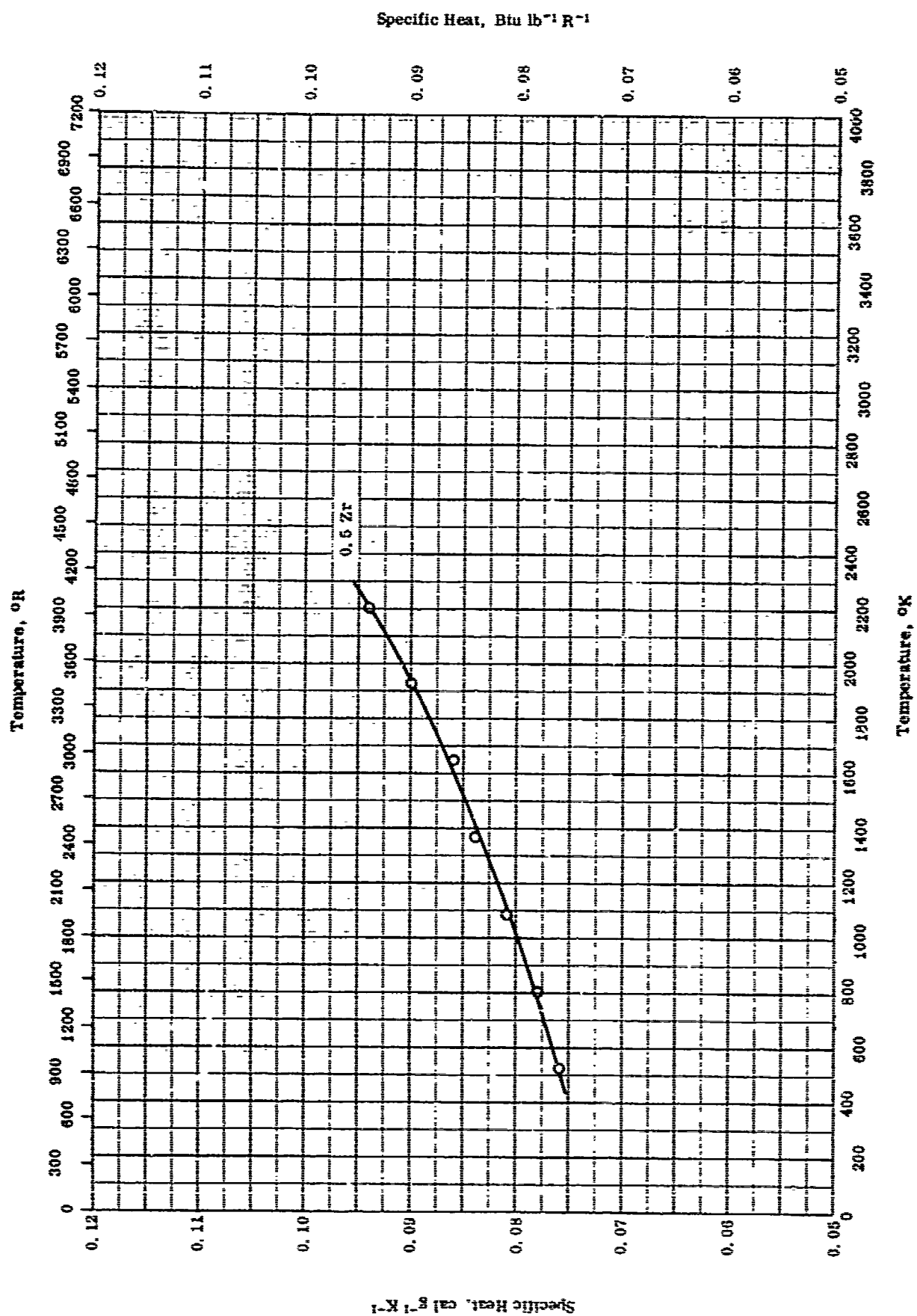
ELECTRICAL RESISTIVITY -- NIOBIUM + ZIRCONIUM

TPRC

D
ELECTRICAL RESISTIVITY -- NIOBIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Repl. Error % | Sample Specifications | Remarks |
|------------|------|--------------------|------------------|-----------------------|--|
| O | 62-4 | 298-1978 | 2.4 | 99.2 Nb and 0.5 Zr. | Hot pressed; maximum exposure temperature 4480 F. |

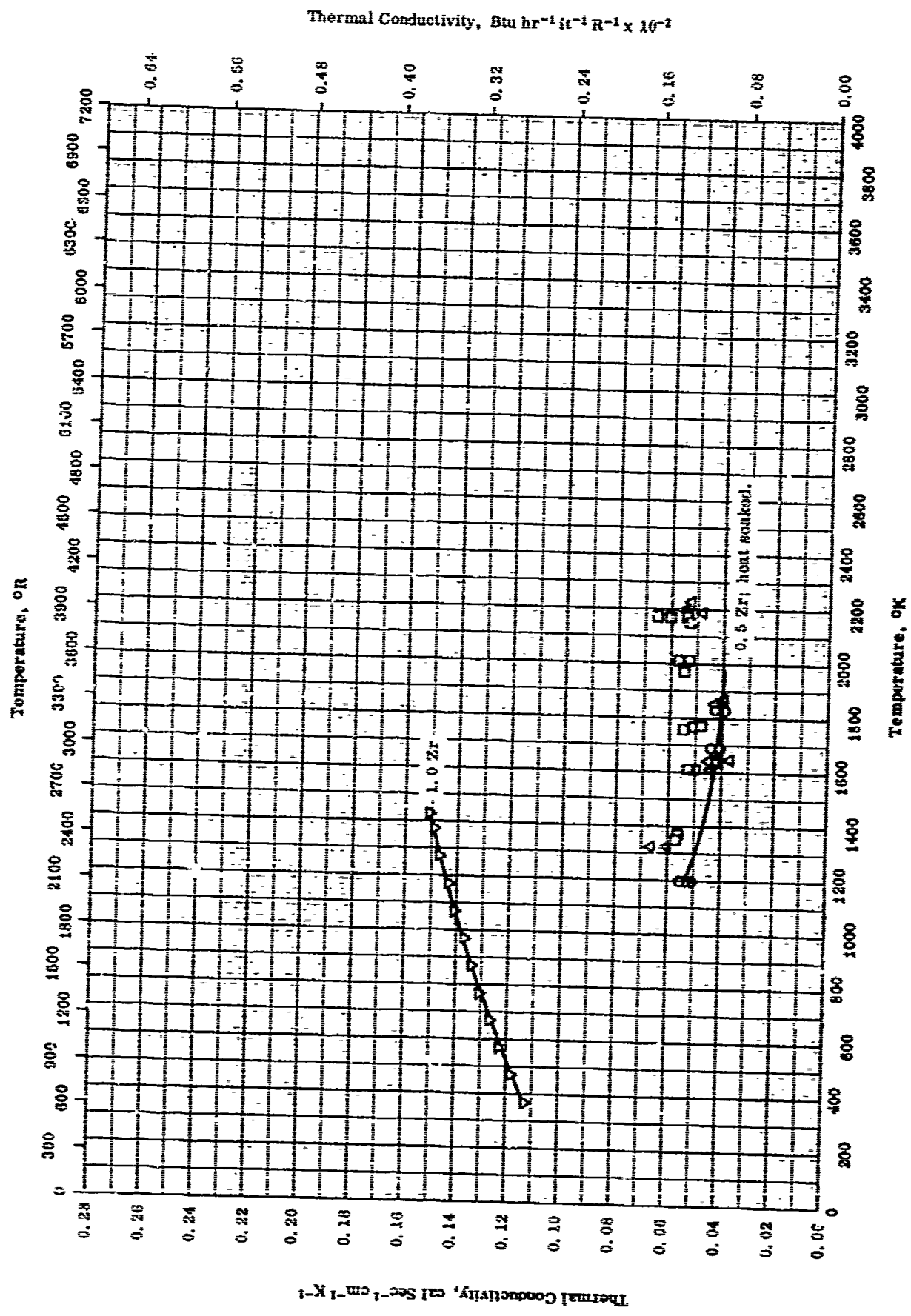


SPECIFIC HEAT -- NIOBIUM + ZIRCONIUM

SPECIFIC HEAT -- NIOBIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---|
| O | 62-4 | 533-2200 | ±5.0 | Cb + 0.5% Zr; before test; 99.2 Nb, 0.6 Zr, <0.1 total elementals; density 505 lb ft ⁻³ , after test; 99.6 Nb, 0.41 C; density 529 lb ft ⁻³ . | Crushed in hardened steel mortar to pass 100-mesh screen; hot pressed. |



Thermal Conductivity -- NIOBIUM + ZIRCONIUM

THERMAL CONDUCTIVITY -- NIOBIUM + ZIRCONIUM

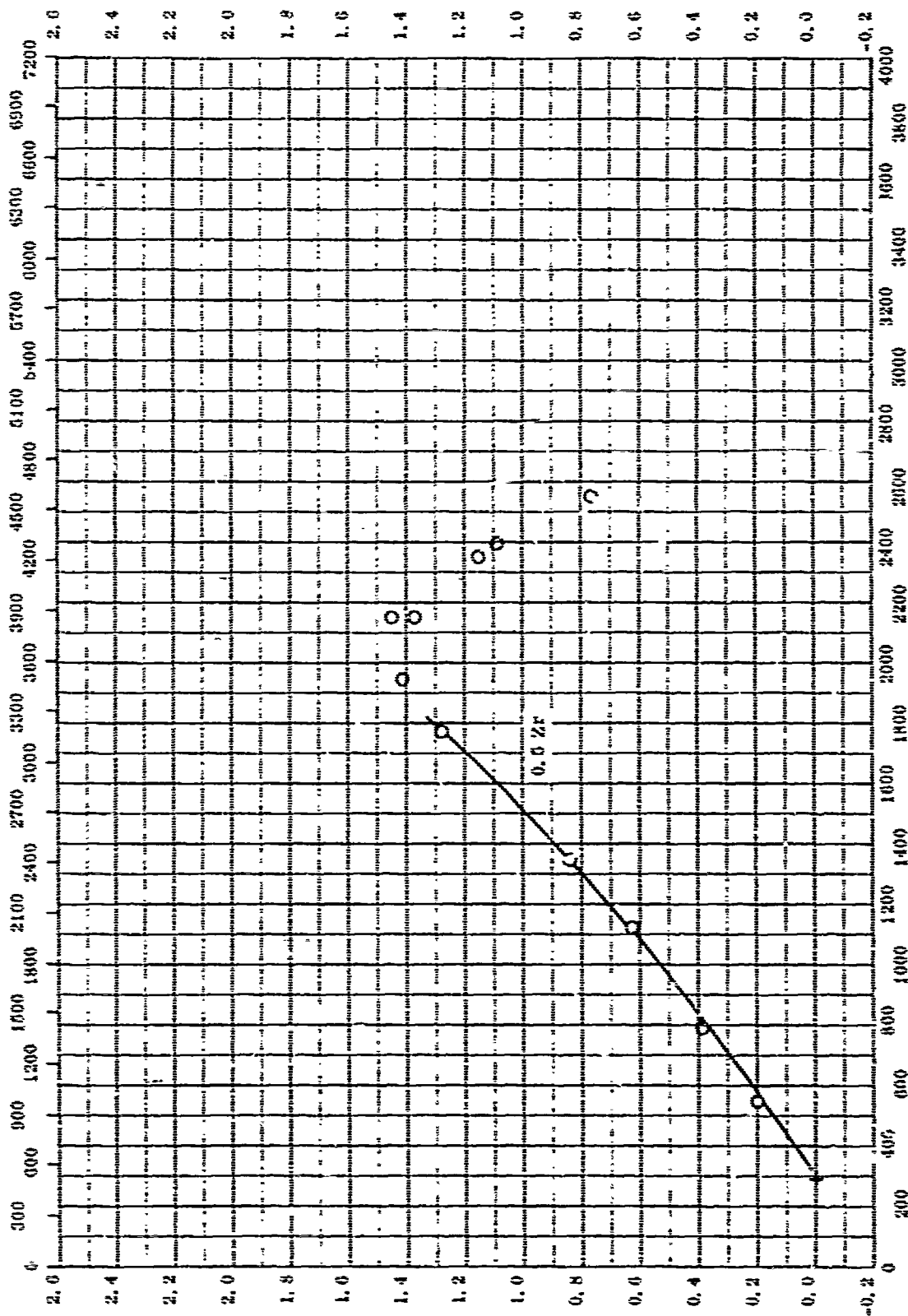
REFERENCE INFORMATION

| Sym [61] | Ref. | Temp. Range °K | Temp. Error % | Sample Specifications | Remarks |
|-------------|------|-------------------|------------------|-----------------------|---|
| ○ | 62-4 | 1200-1800 | 5-7 | 0.5 Zr. | Ground and polished to eliminate all scratches on the surface of the sample; heat soaked at 3350 F. |
| □ | 62-4 | 1353-2178 | 5-7 | 0.5 Zr. | Same as above except sample being partially melted. |
| △ | 62-4 | 1322-2226 | 5-7 | 0.5 Zr. | Same as above; sample found unmelted but color changed. |
| ▽ | 63-7 | 373-1423 | ±3 | 1.0 Zr. | |

Thermal Linear Expansion, percent

355

Temperature, °R



Temperature, °K

THERMAL LINEAR EXPANSION -- NIOBIUM + ZIRCONIUM

Thermal Linear Expansion, percent

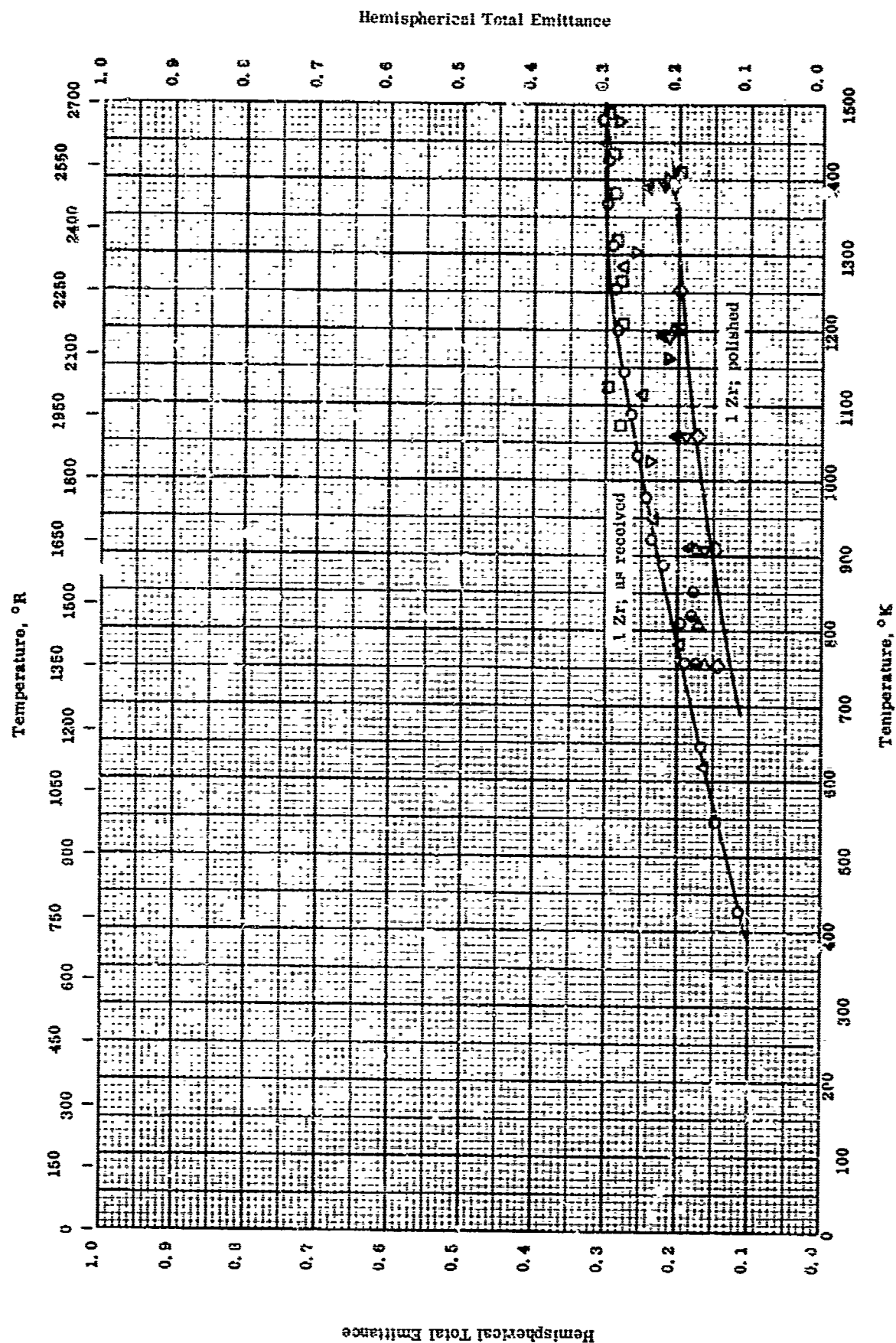
TPRC

THERMAL LINEAR EXPANSION -- NIOBIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---|
| ○ | 62-4 | 294-2628 | 5 | General Astrometals Corp. ; 99.2 Nb and 0.5 Zr and after exposure 99.5 Nb and 0.41 C; density 7.88 g cm ⁻³ and after exposure 8.32 g cm ⁻³ . | Hot pressed; measured in helium atmos; specimen melted. |

TIRC

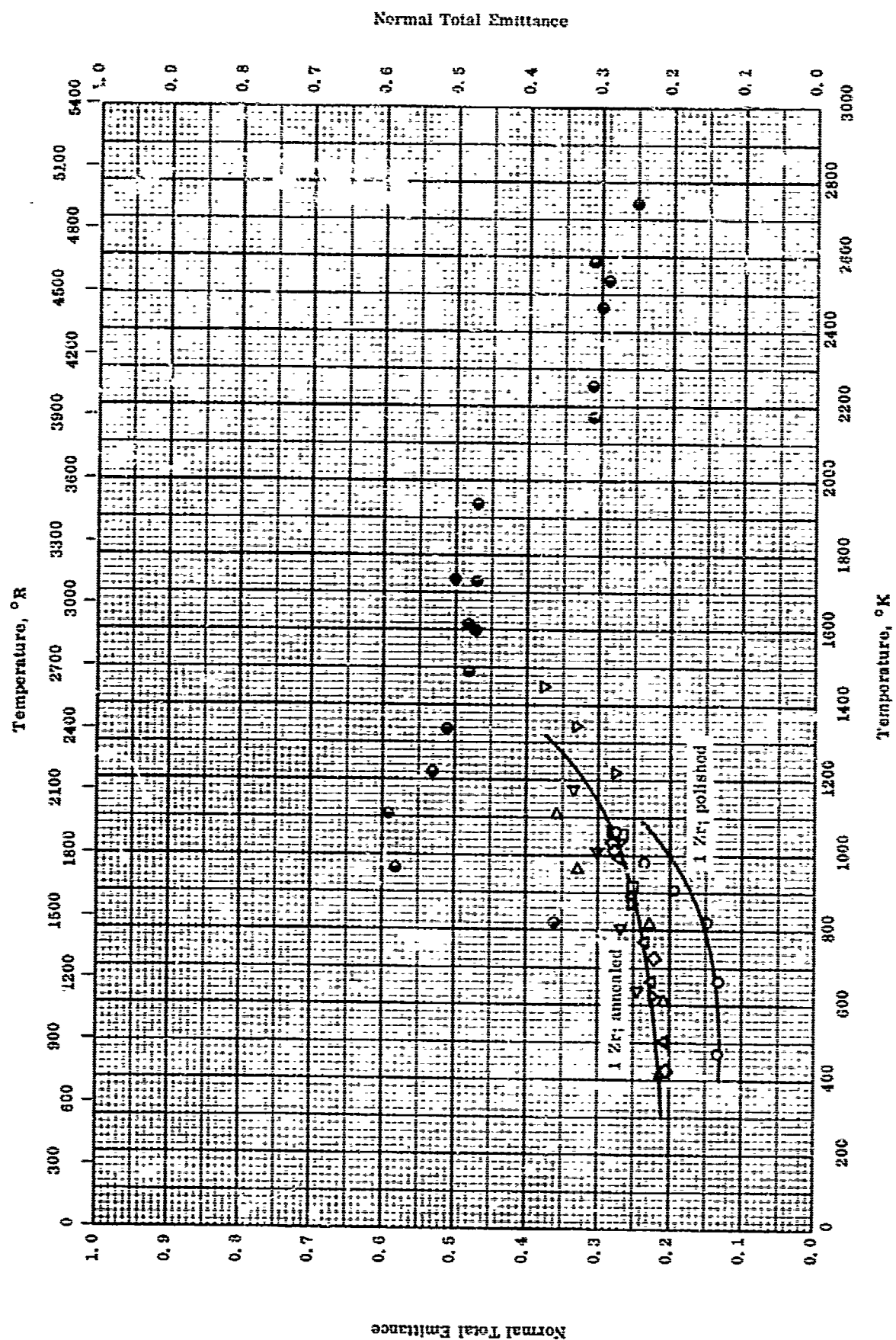


HEMISPHERICAL TOTAL EMITTANCE -- NIOBIUM + ZIRCONIUM

HEMISPHERICAL TOTAL EMITTANCE -- NIOBIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---|
| ○ | 64-6 | 428-1479 | | 1 Zr; commercial. | As received; a vacuum of 2.1×10^{-3} mm Hg or higher; heating. |
| △ | 64-6 | 818-1450 | | 1 Zr; commercial. | The above specimen; cooling. |
| □ | 64-6 | 1075-1469 | | 1 Zr; commercial. | As received; a vacuum of 2.1×10^{-4} mm Hg or higher; heating. |
| ▽ | 64-6 | 1127-1479 | | 1 Zr; commercial. | The above specimen; cooling. |
| ◇ | 64-6 | 755-1394 | | 1 Zr; commercial. | Polished; a vacuum of 2.0×10^{-6} mm Hg or higher; first run. |
| ▽ | 64-6 | 757-1393 | | 1 Zr; commercial. | The above specimen; second run. |
| △ | 64-6 | 755-1393 | | 1 Zr; commercial. | The above specimen; third run. |
| ⊙ | 64-6 | 757-1393 | | 1 Zr; commercial. | The above specimen; fourth run. |
| ▲ | 64-6 | 757-1391 | | 1 Zr; commercial. | The above specimen; fifth run. |
| ■ | 64-6 | 1202-1411 | | 1 Zr; commercial. | Polished; a vacuum of 2.0×10^{-6} mm Hg or higher; first run. |
| ▼ | 64-6 | 1163-1403 | | 1 Zr; commercial. | The above specimen; second run. |



NORMAL TOTAL EMITTANCE --- NIOBIUM + ZIRCONIUM

NORMAL TOTAL EMITTANCE -- NIOBIUM + ZIRCONIUM

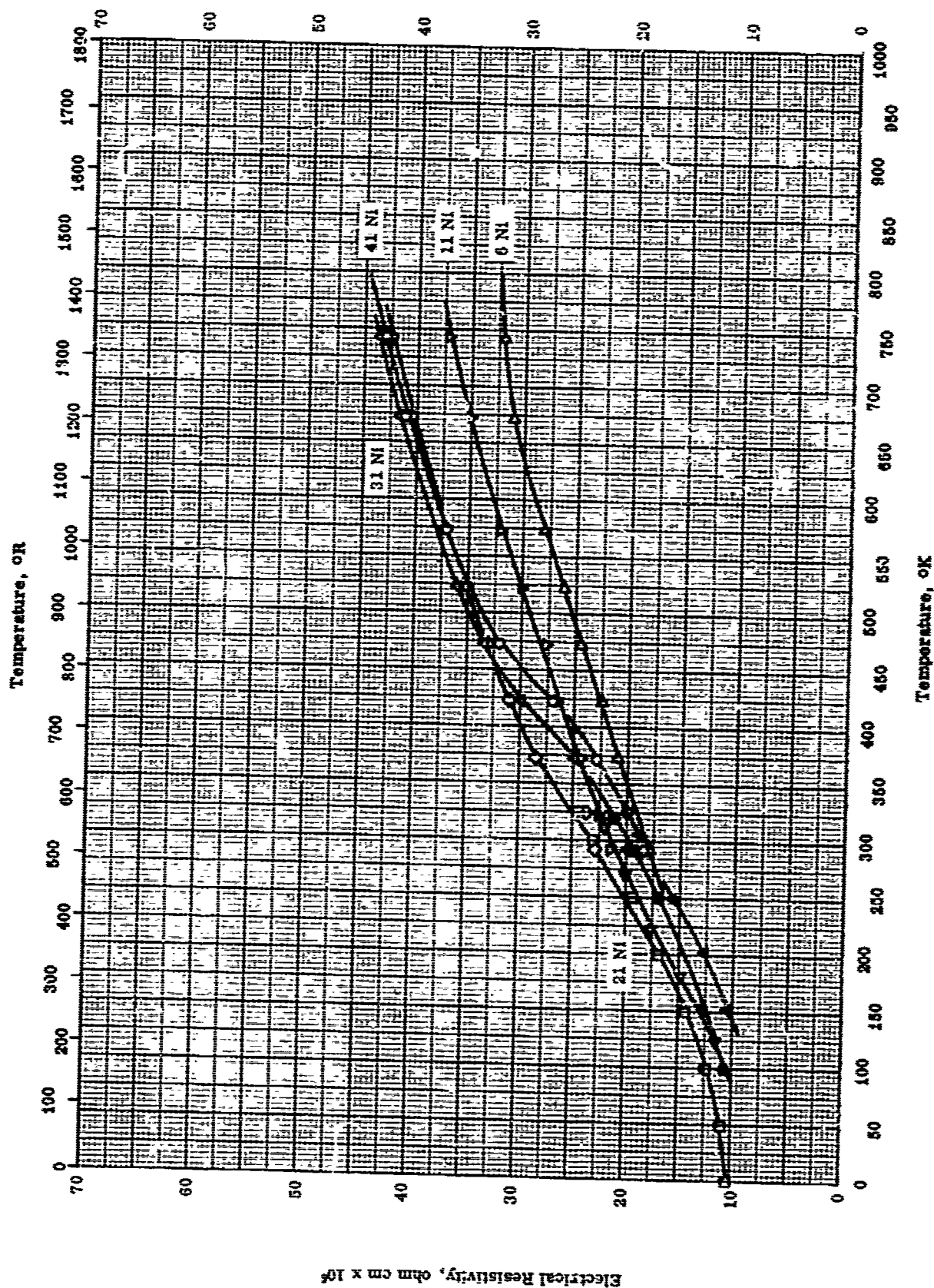
REFERENCE INFORMATION

| Sym Bol | Rat. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 63-20 | 474-1060 | ± 2.7 | 1 Zr. | Rough hand-polished with 4-P metallographic paper, A and B alumina, and diamond paste; 5×10^{-6} mm Hg vacuum; heating. |
| △ | 63-20 | 506-904 | ± 2.7 | 1 Zr. | The above specimen, cooling. |
| □ | 63-20 | 919-1059 | ± 2.7 | 1 Zr. | The above specimen annealed; cooling. |
| ◇ | 63-20 | 431-1045 | ± 2.7 | 1 Zr. | Same surface treatment as above, annealed; cooling. |
| ▽ | 63-20 | 628-1452 | ± 2.7 | 1 Zr. | ing. |
| ▽ | 63-20 | 641-1177 | ± 2.7 | 1 Zr. | The above specimen heated to 1200 C. |
| △ | 63-20 | 424-1111 | ± 2.7 | 1 Zr. | The above specimen cooled from 1200 C. |
| ● | 62-4 | 322-2744 | 10 | 0.5 Zr. | Roughened to rms 45μ in.; 5×10^{-6} mm Hg vacuum; heating. Measured in argon atmosphere. |

TPRC

Electrical Resistivity, ohm cm x 10⁶

291



ELECTRICAL RESISTIVITY -- PALLADIUM + NICKEL

REFERENCE INFORMATION

| Spec. Sol. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|----------------|---------------|-----------------------|---|
| ○ | 57-20 | 293-743 | | 59.2 Pd and 40.8 Ni. | Annealed for 2 hrs at 1070 K in vacuum and furnace cooled in 24 hrs. |
| △ | 57-20 | 293-743 | | 60.1 Pd and 39.9 Ni. | Same as above. |
| ◇ | 57-20 | 293-743 | | 79.0 Pd and 21.0 Ni. | Same as above. |
| ▽ | 57-20 | 293-743 | | 89.5 Pd and 10.5 Ni. | Same as above. |
| △ | 57-20 | 293-743 | | 94.2 Pd and 5.8 Ni. | Same as above. |
| □ | 58-10 | 0-325 | | 79.4 Pd and 20.6 Ni. | Annealed for 2 hrs at 800 C in vacuum and gradually cooled in 24 hrs. |
| ▽ | 58-19 | 100-325 | | 89.4 Pd and 10.6 Ni. | Same as above. |
| ● | 58-10 | 100-325 | | 70 Pd and 30 Ni. | Same as above. |
| ▲ | 58-19 | 100-325 | | 57.4 Pd and 42.6 Ni. | Same as above. |

PROPERTIES OF PALLADIUM + URANIUM

REPORTED VALUES

Melting Point

K

R

O 42.72 U

1913

3444

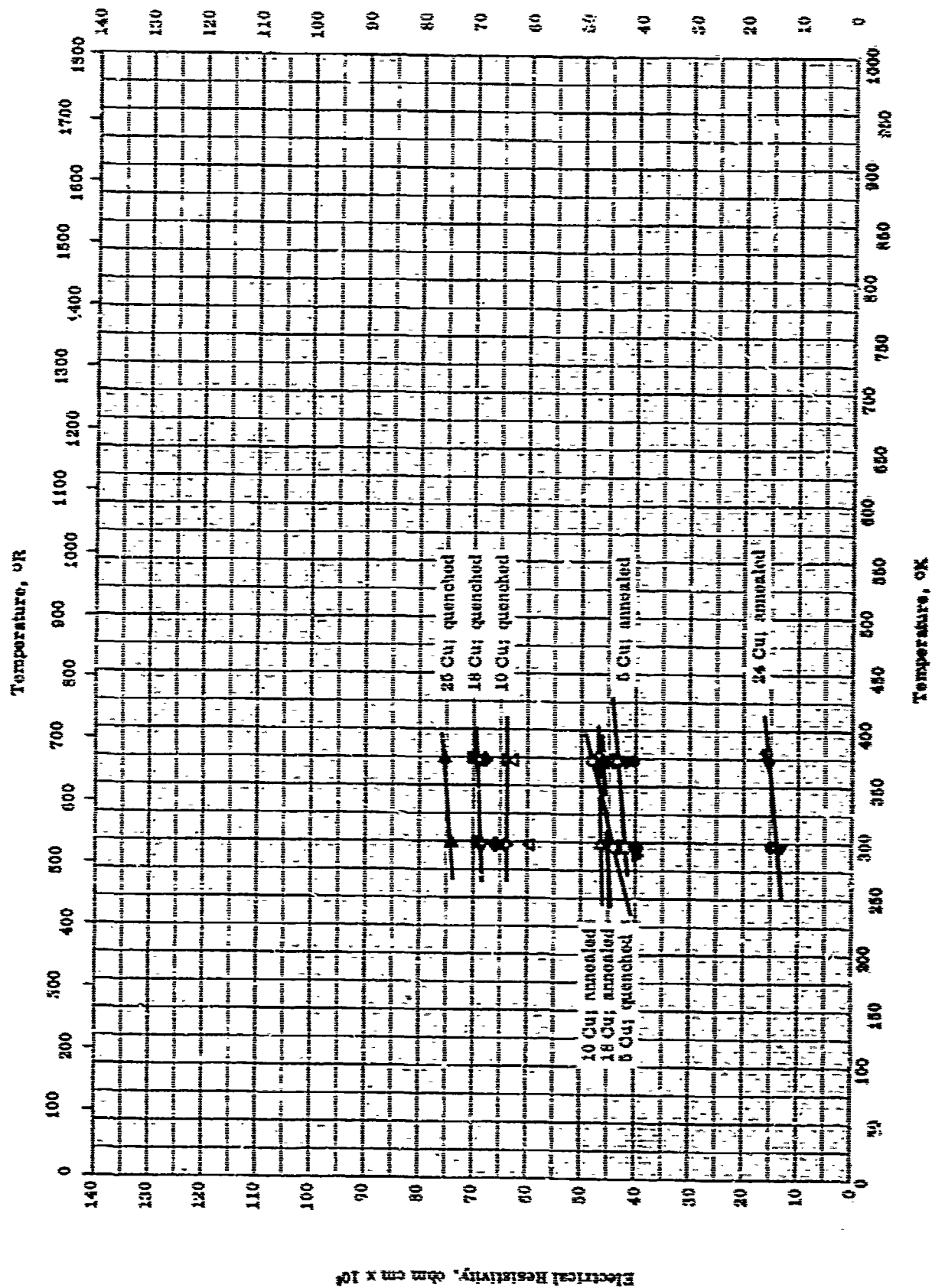
PROPERTIES OF PALLADIUM + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| O | 58-36 | 1913 | | UPd ₃ ; 57.28 Pd and 42.72 U. | M. P. from break in time-temperature curve. |

Electrical Resistivity, ohm cm x 10⁴

395



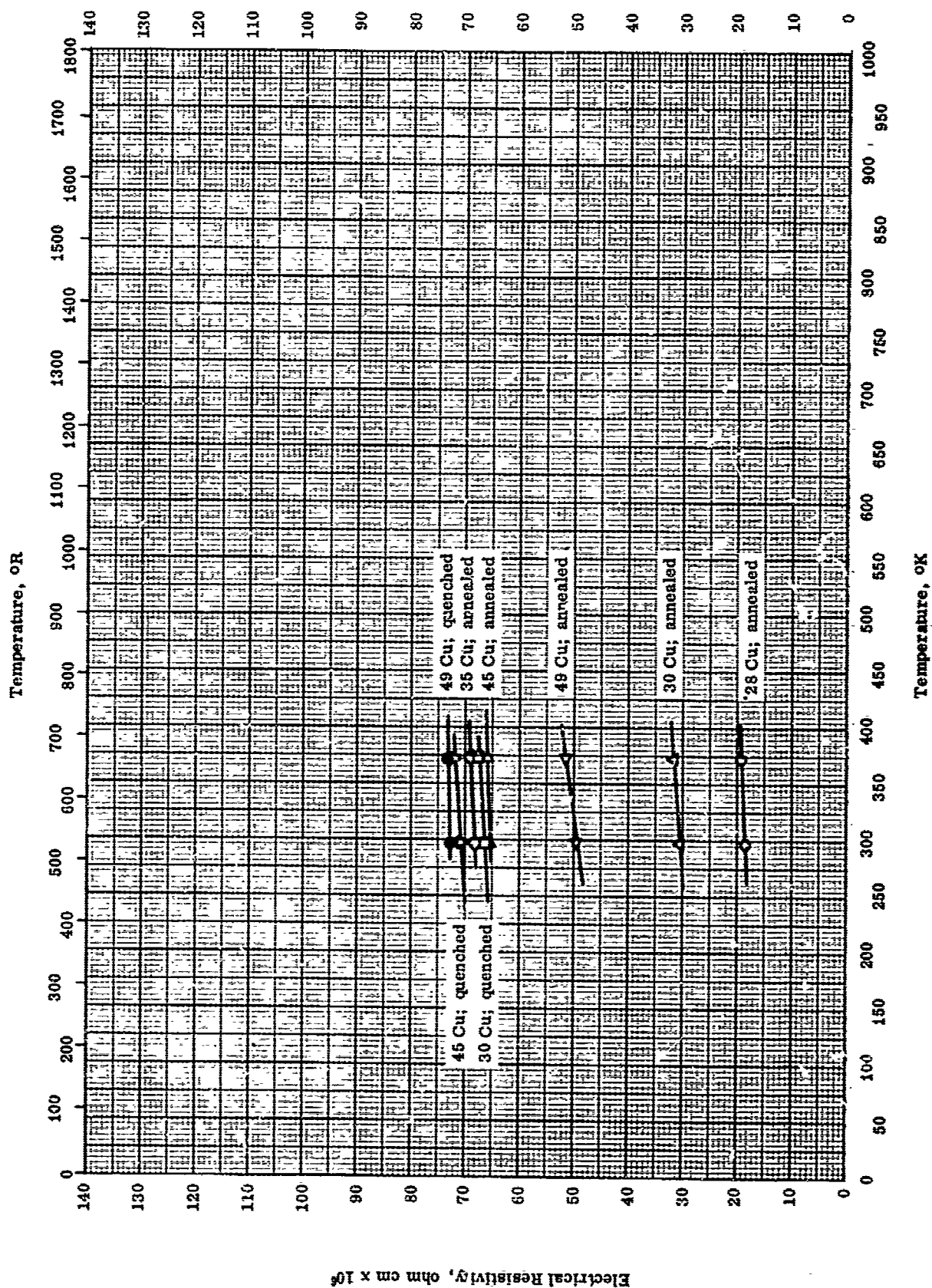
ELECTRICAL RESISTIVITY -- PLATINUM-COPPER
(4 - 26 Cu)

ELECTRICAL RESISTIVITY -- PLATINUM + COPPER
(4 - 2% Cu)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------------------|
| ○ | 56-27 | 298-373 | | 4.54 Cu. | Quenched from 900 C. |
| □ | 56-27 | 298-373 | | Same as above. | Annealed. |
| △ | 56-27 | 298-373 | | 7.45 Cu. | Quenched from 900 C. |
| ◇ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ▽ | 56-27 | 298-373 | | 10.09 Cu. | Quenched from 900 C. |
| △ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ▽ | 56-27 | 298-373 | | 12.45 Cu. | Quenched from 900 C. |
| ● | 56-27 | 298-373 | | Same as above. | Annealed. |
| ■ | 56-27 | 298-373 | | 17.56 Cu. | Quenched from 900 C. |
| ▲ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ◆ | 56-27 | 298-373 | | 21.56 Cu. | Quenched from 900 C. |
| ▼ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ◀ | 56-27 | 298-373 | | 23.22 Cu. | Same as above. |
| ▶ | 56-27 | 298-373 | | 24.76 Cu. | Quenched from 900 C. |
| ○ | 56-27 | 298-373 | | Same as above. | Annealed. |

TPAC



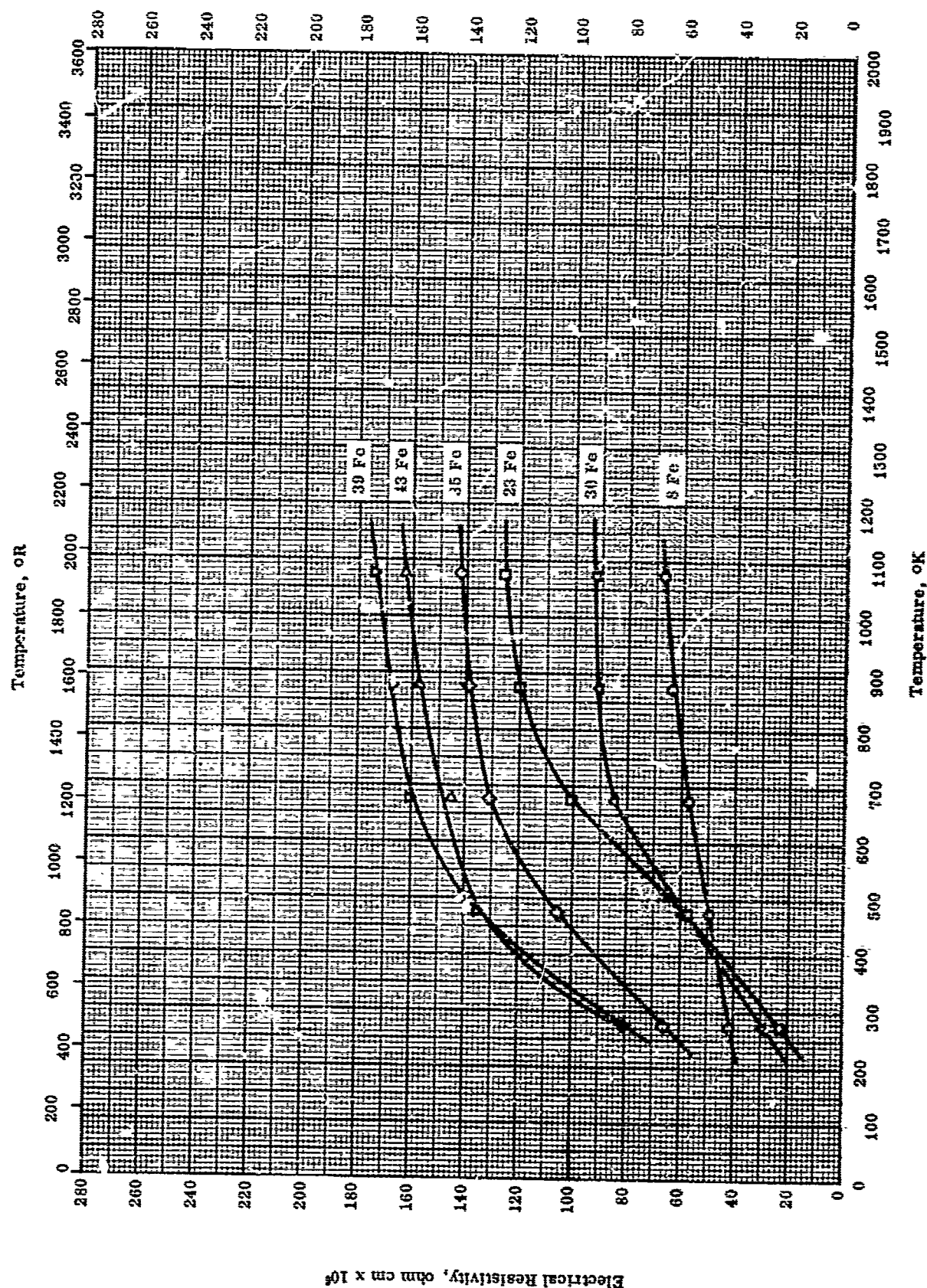
ELECTRICAL RESISTIVITY -- PLATINUM + COPPER
(25-50 Cu)

ELECTRICAL RESISTIVITY -- PLATINUM + COPPER
(25-50 Cu)

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------------------|
| ○ | 56-27 | 298-373 | | 28.14 Cu. | Annealed. |
| □ | 56-27 | 298-373 | | 30.15 Cu. | Quenched from 900 C. |
| △ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ◇ | 56-27 | 298-373 | | 34.73 Cu. | Annealed. |
| ▽ | 56-27 | 298-373 | | 44.82 Cu. | Quenched from 900 C. |
| △ | 56-27 | 298-373 | | Same as above. | Annealed. |
| ● | 56-27 | 298-373 | | 49.14 Cu. | Quenched from 900 C. |
| ▽ | 56-27 | 298-373 | | Same as above. | Annealed. |

TPRC



ELECTRICAL RESISTIVITY --- PLATINUM + IRON

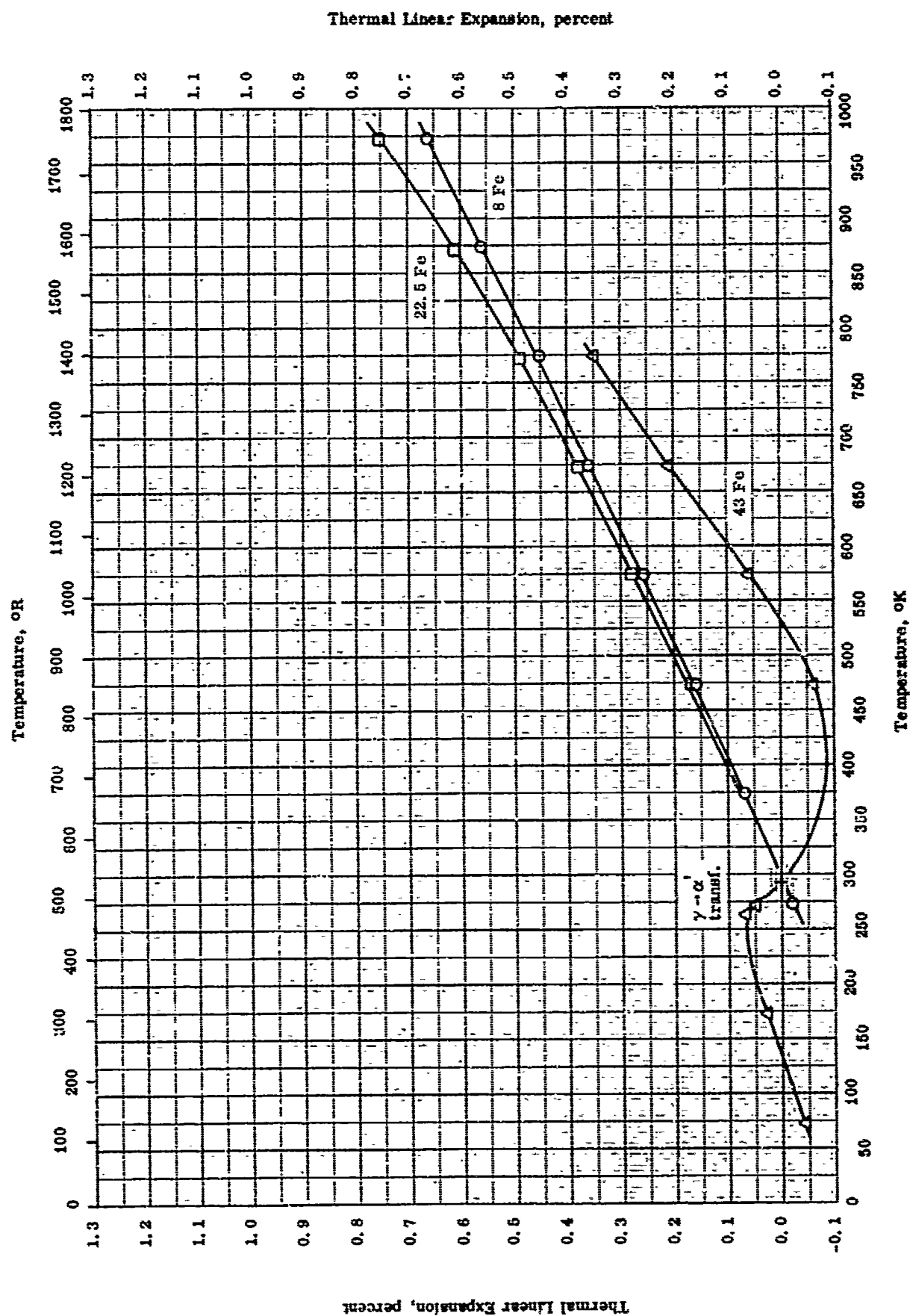
TPRC

ELECTRICAL RESISTIVITY -- PLATINUM + IRON

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---|
| ○ | 50-6 | 273-1073 | | 92 Pt and 8 Fe; prepared from Armco Fe and technically pure Pt. | Induction melted in MgO crucible; tempered. |
| □ | 50-6 | 273-1073 | | 77.5 Pt and 22.5 Fe; prepared as above. | Same as above. |
| △ | 50-6 | 273-1073 | | 70 Pt and 30 Fe; prepared as above. | Same as above. |
| ◇ | 50-6 | 273-1073 | | 65 Pt and 35 Fe; prepared as above. | Same as above. |
| ▽ | 50-6 | 273-1073 | | 61 Pt and 39 Fe; prepared as above. | Same as above. |
| △ | 50-6 | 273-1073 | | 57 Pt and 43 Fe; prepared as above. | Same as above. |

TPRC

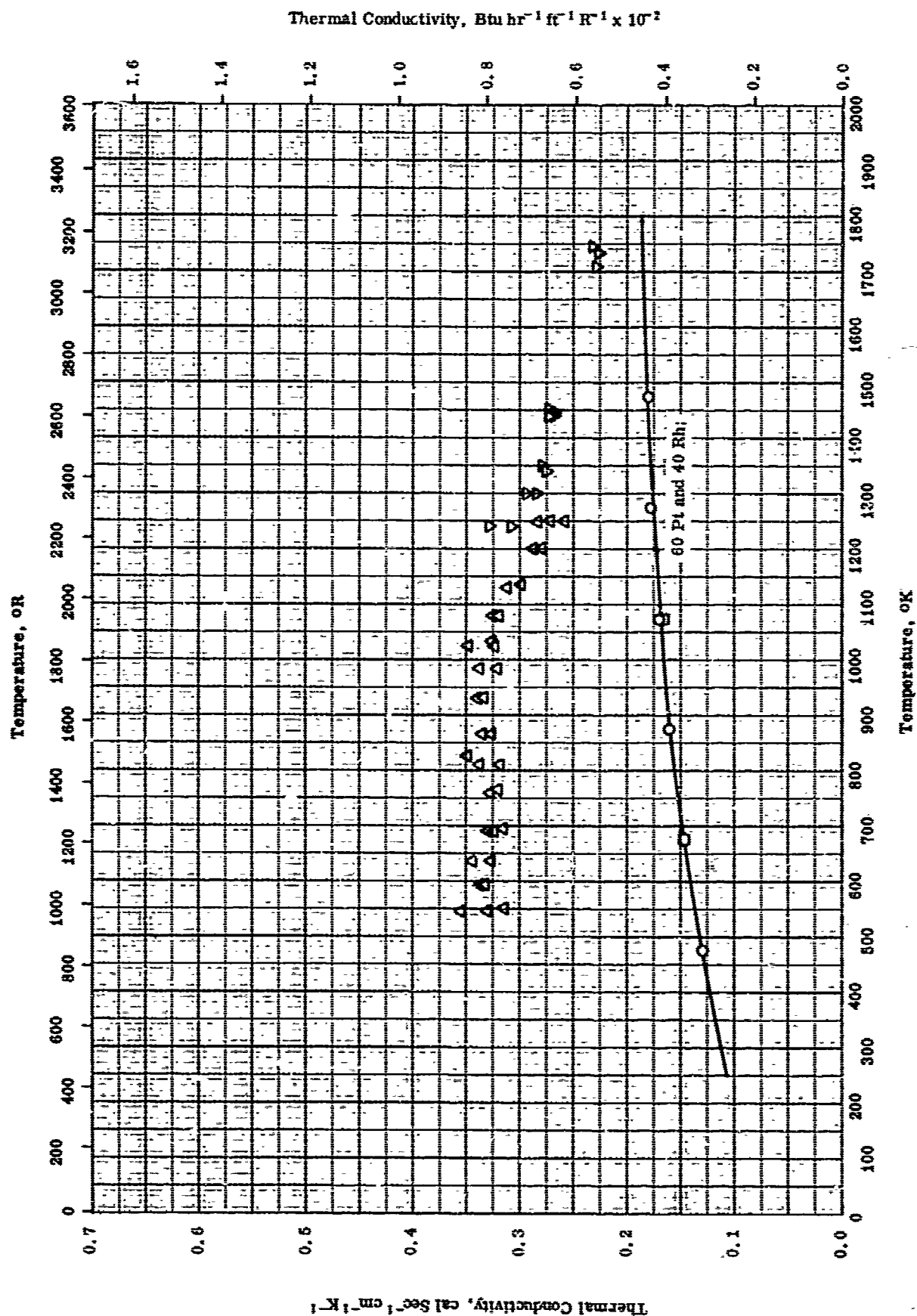


THERMAL LINEAR EXPANSION -- PLATINUM + IRON

THERMAL LINEAR EXPANSION -- PLATINUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|--------------------|------------------|-----------------------|--|
| ○ | 50-6 | 273-773 | | 92 Pt and 8 Fe. | Prepared from Armeo iron and technically pure platinum, melted in magnesia crucible, formed into rods; tempered. |
| □ | 50-6 | 273-973 | | 77.5 Pt and 22.5 Fe. | Same as above. |
| △ | 50-6 | 73-773 | | 57 Pt and 43 Fe. | Same as above. |

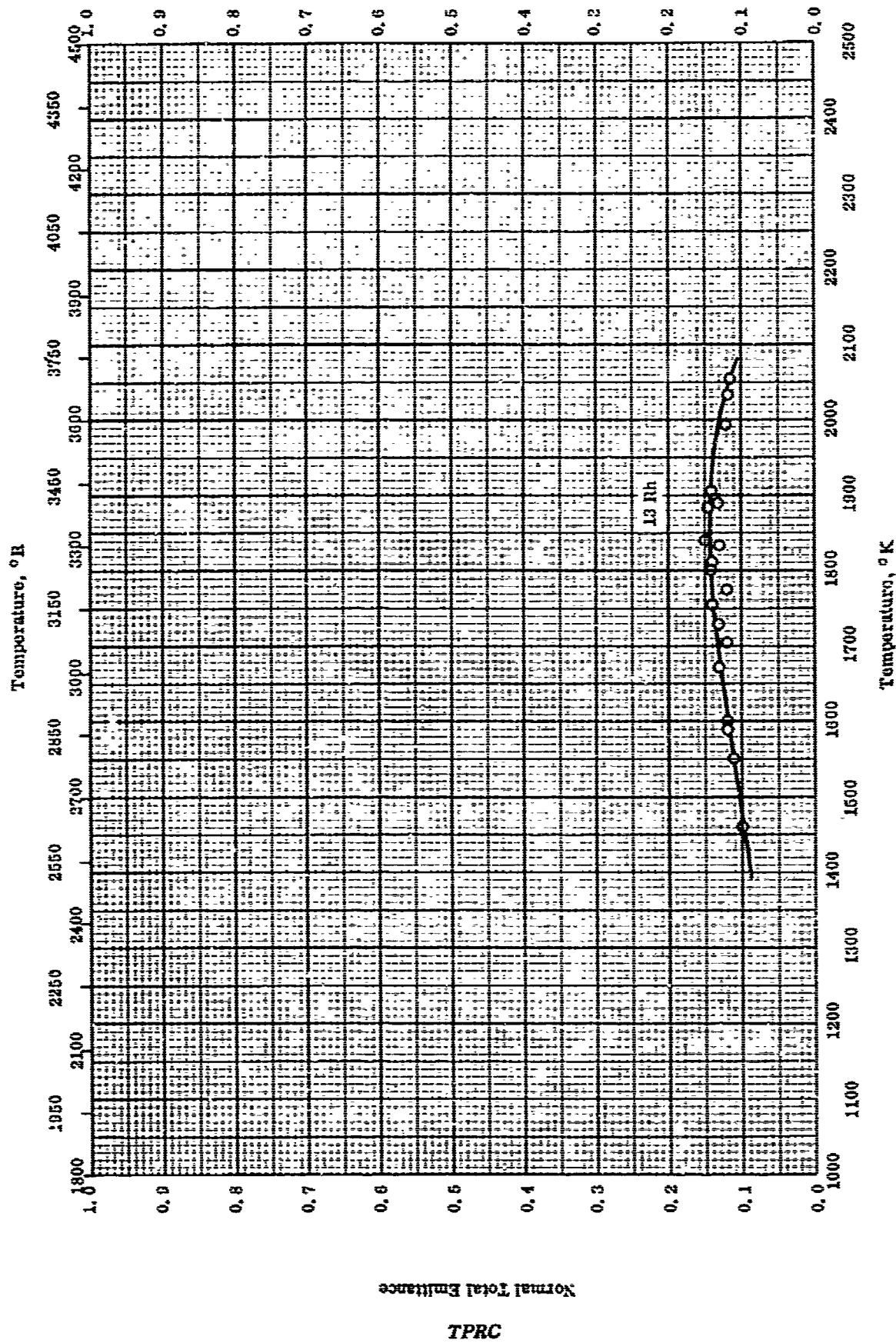


THERMAL CONDUCTIVITY -- PLATINUM + RHODIUM

THERMAL CONDUCTIVITY -- PLATINUM + RHODIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|------------------------------------|
| ○ | 62-10 | 473-1473 | | 60 Pt, 40 Rh, 0.01-0.1 Fe, 0.001-0.01 Cu, Ir, Pd, Si, and Zr, and 0.001 % B and Ca. | Machined and annealed at 1000 C. |
| □ | 62-10 | 673-1073 | | Same as above. | Cooling curve of the above sample. |
| △ | 62-12 | 548-1254 | | 60 Pt and 40 Rh; grain size exhibited an increase of 2 to 3 times larger than those before measurement. | Annealed at 1800 F for 30 min. |
| ▽ | 62-12 | 1240-1747 | | Same as above. | Second run. |

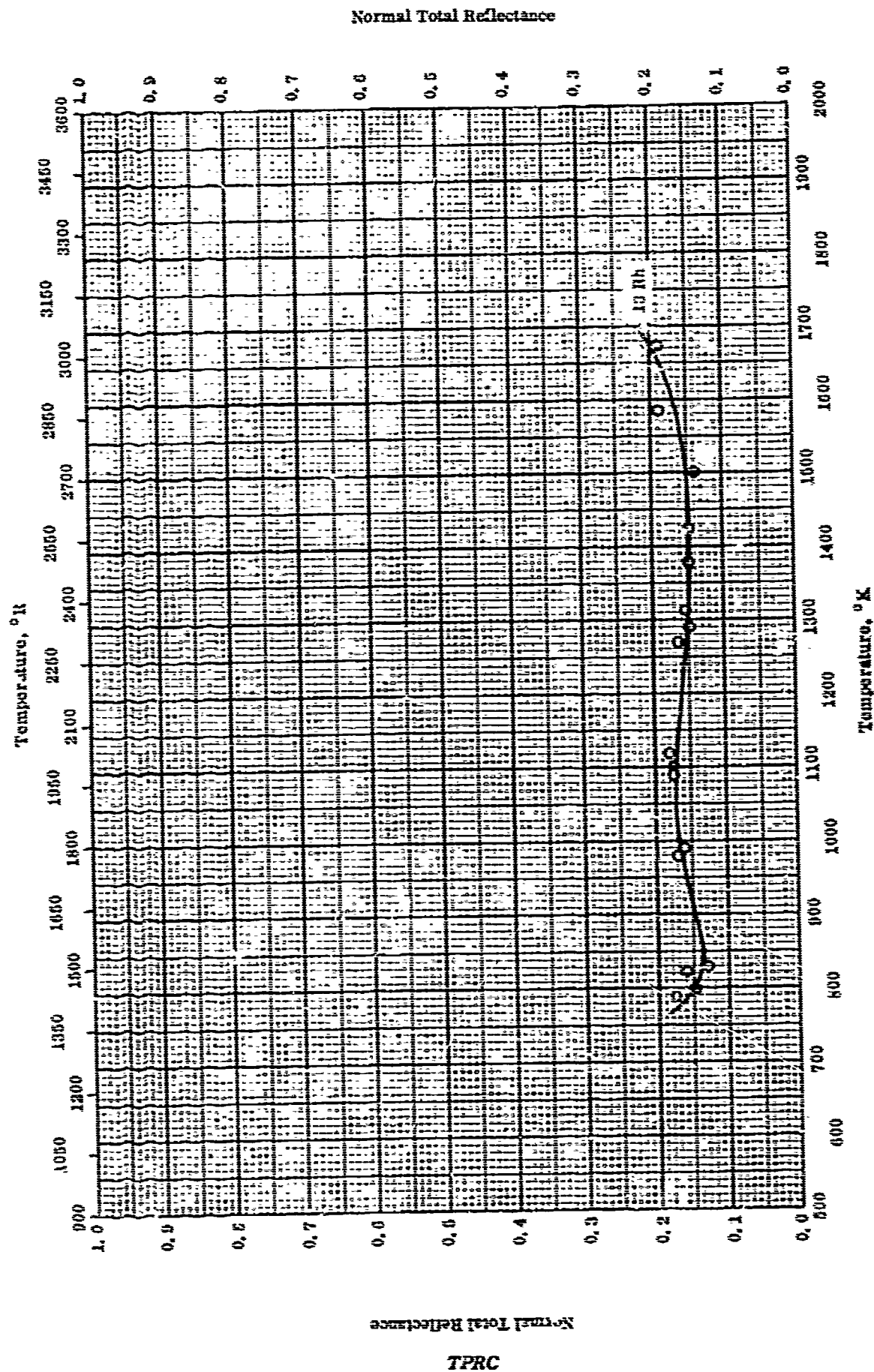


NORMAL TOTAL EMITTANCE -- PLATINUM + RHODIUM

NORMAL TOTAL EMITTANCE --- PLATINUM + RHODIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|-------|--------------------|-------------------|-----------------------|-------------|
| O | 62-19 | 1461-2055 | ± 10 | 87 Pt and 13 Rh. | This sheet. |



NORMAL TOTAL REFLECTANCE -- PLATINUM + IRIDIUM

NORMAL TOTAL REFLECTANCE -- PLATINUM + RHODIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| O | 62-18 | 789-1672 | | 87 Pt and 13 Rh. | Annealed in air at 1856 K for 1 hr.; measured in nitrogen atmosphere. |

TPRC

PROPERTIES OF PLUTONIUM + OSMIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| O 3 Os | 18.3 | 1140 |

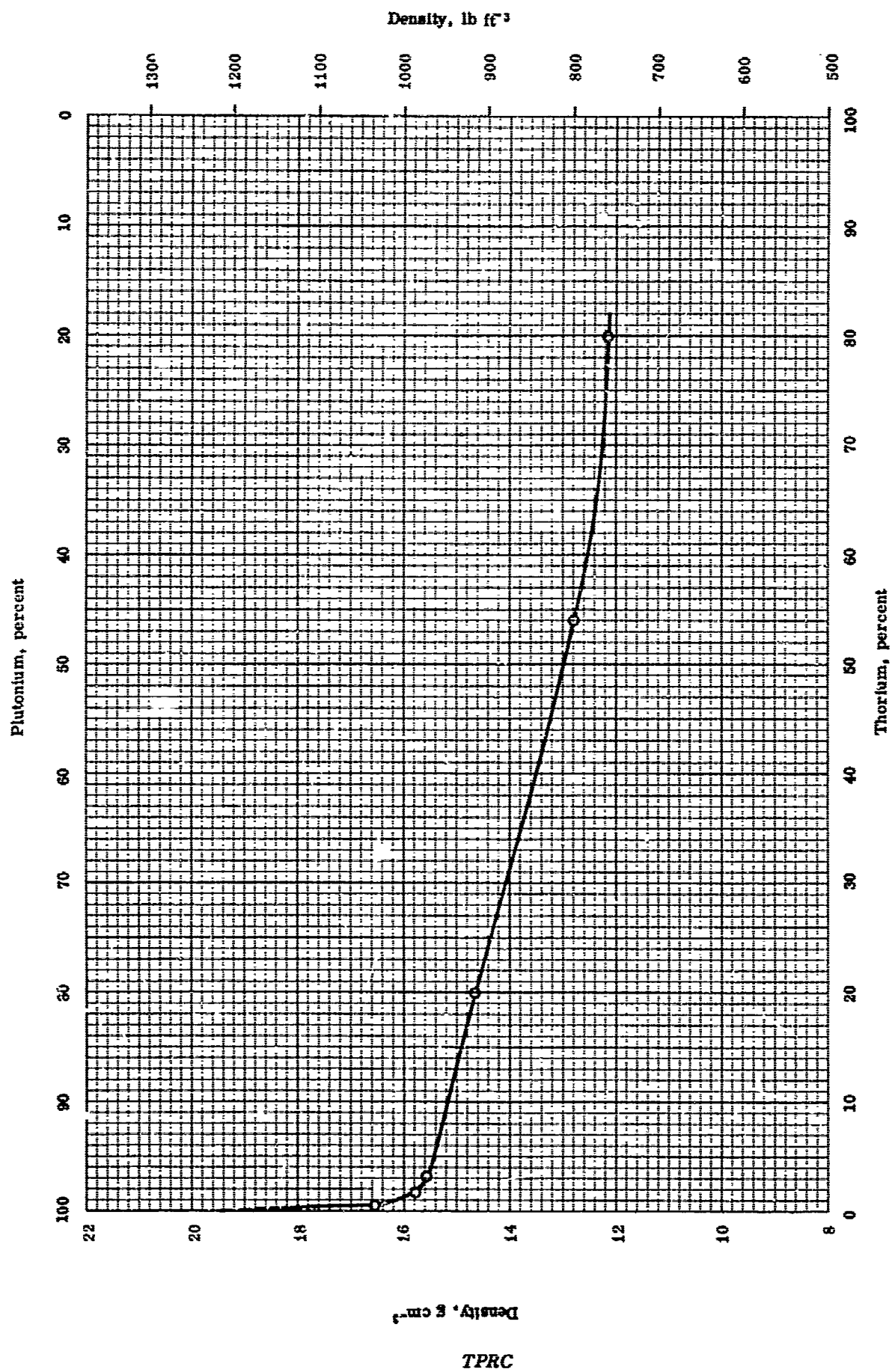
TPRC

PROPERTIES OF PLUTONIUM + OSMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rpt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-----------------------|---------|
| O | 55-29 | 298 | | 3 Os; eta-phase. | |

TPRC



DENSITY -- PLUTONIUM + THORIUM

DENSITY -- PLUTONIUM + THORIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|-----------------------|--|
| O | 57-33 also 57-37 | 300 | | 0 - 80 Th. | As cast; density from weight in air, in water, and in ethylene bromide. |

TPRC

PROPERTIES OF PRASEODYMIUM + MAGNESIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|------------|--------------------|---------------------|
| O 1.0 > Mg | 6.6 | 411 |

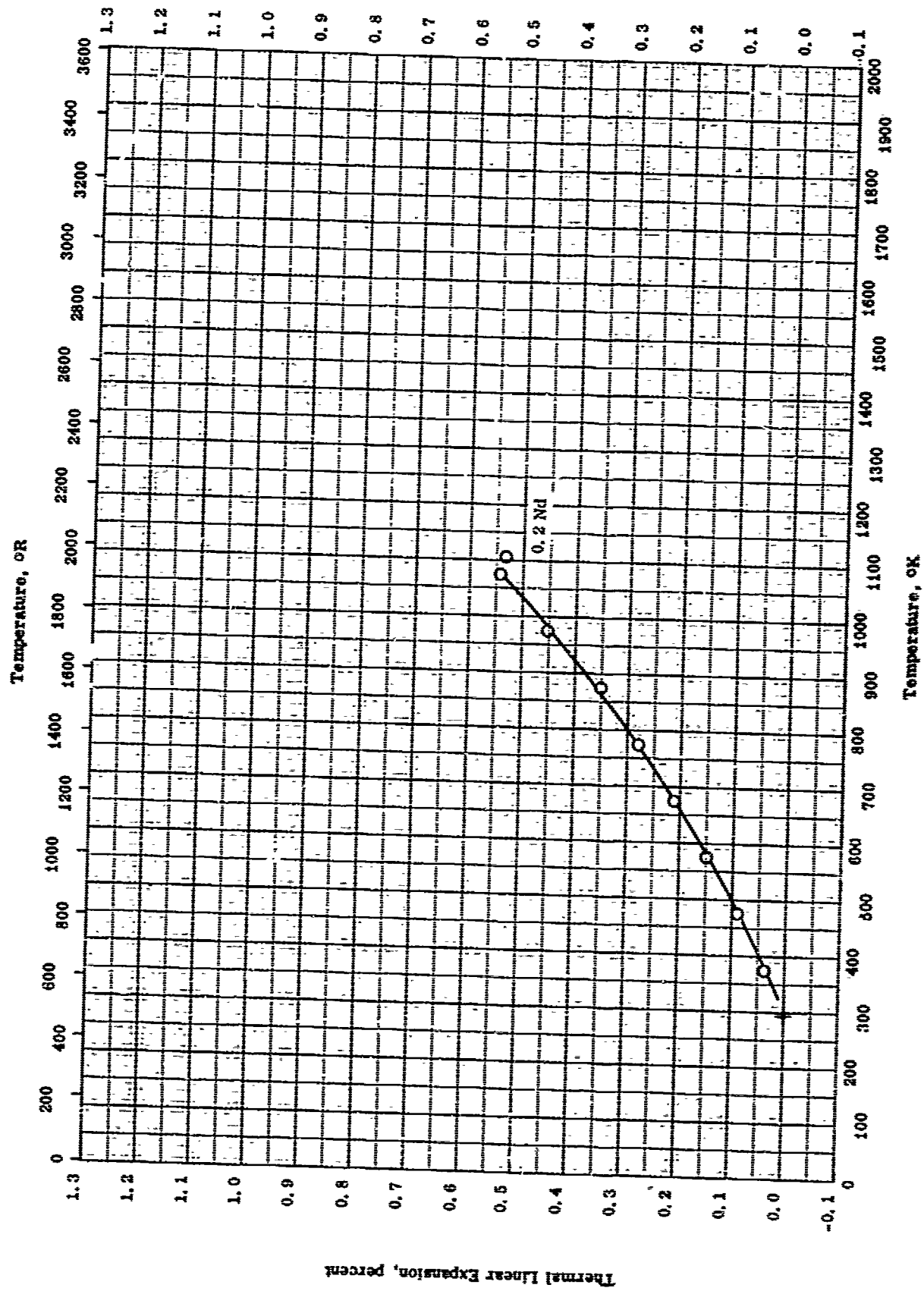
PROPERTIES OF PRASEODYMIUM + MAGNESIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---------------------------------|
| C | 52-11 | 298 | | 1.0 > Mg, 0.025 > Ca, 0.0135 Fe, and 0.01 > other rare earths; 75 % hexagonal close packed and 25 % face centered cubic phases. | Cnst; annealed 19 hrs at 600 C. |

Thermal Linear Expansion, percent

415



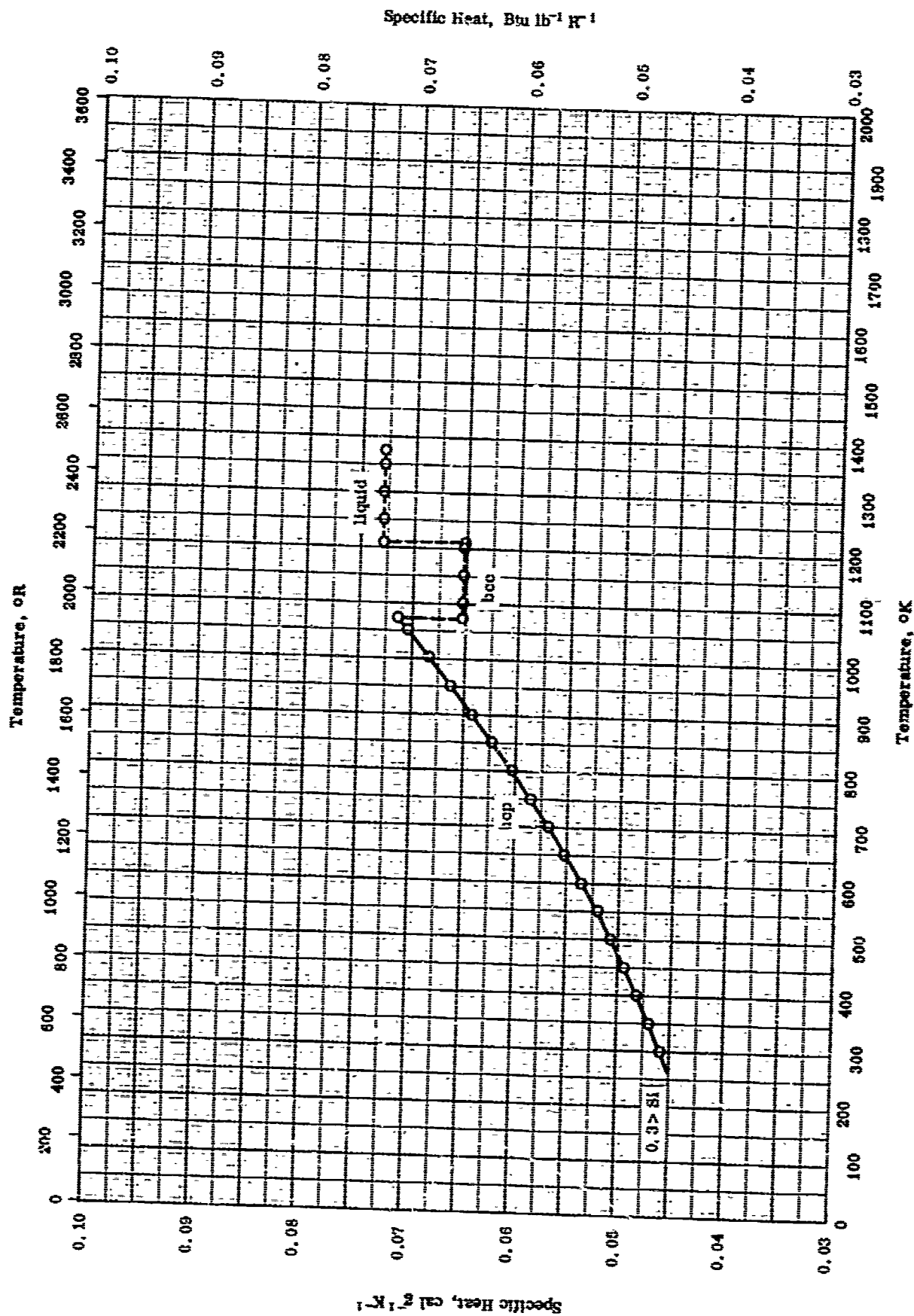
THERMAL LINEAR EXPANSION -- PRASEODYMIUM + NEODYMIUM

TPRC

THERMAL LINEAR EXPANSION -- PRASEODYMIUM + NEODYMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|--|--|
| O | 56-42 also 57-51 | 293-1103 | ± 1 | 0.2 Nd, 0.1 Ce, 0.05 N, 0.03 C, Ta, Si each, 0.01 La, and 0.006 Fe. | Fluoride reduced with Ca, vacuum cast, recast into rod; tested in He; data obtained during heating, cooling data not shown because sample softened. |



SPECIFIC HEAT -- PRASEODYMIUM + SILICON

SPECIFIC HEAT -- PRASEODYMIUM + SILICON

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| O | 62-14 | 273-1373 | | 99.23 < Pr, 0.3 > Si, 0.10 > Ce, 0.10 > La, 0.10 > Nd, 0.10 > Ta, 0.06 > Ca, 0.01 > Fe, and 0.01 > Mg. | Prepared by metallothermic reduction of praseodymium fluoride with calcium metal; sealed under helium atmosphere. |

PROPERTIES OF RHENIUM + TUNGSTEN

REPORTED VALUES

Melting Point:

K

R

O 33 W

3083

5550

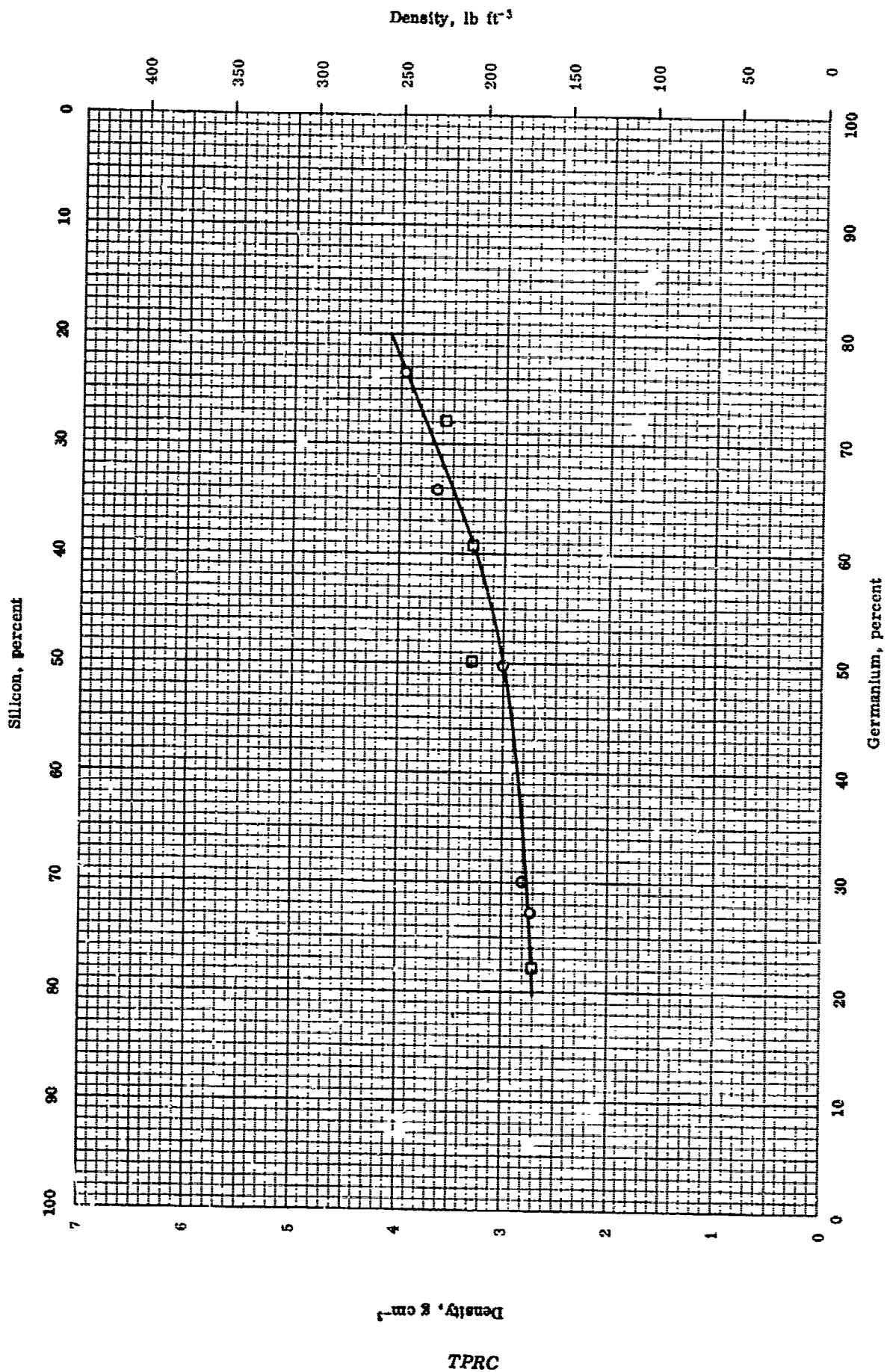
TPRC

PROPERTIES OF RHENIUM-TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Acft. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| O | 55-33 | 3083 | | 33 W. | M. P. from collapse of hole; the lowest melting eutectic for whole Re-W system. |

TPRC

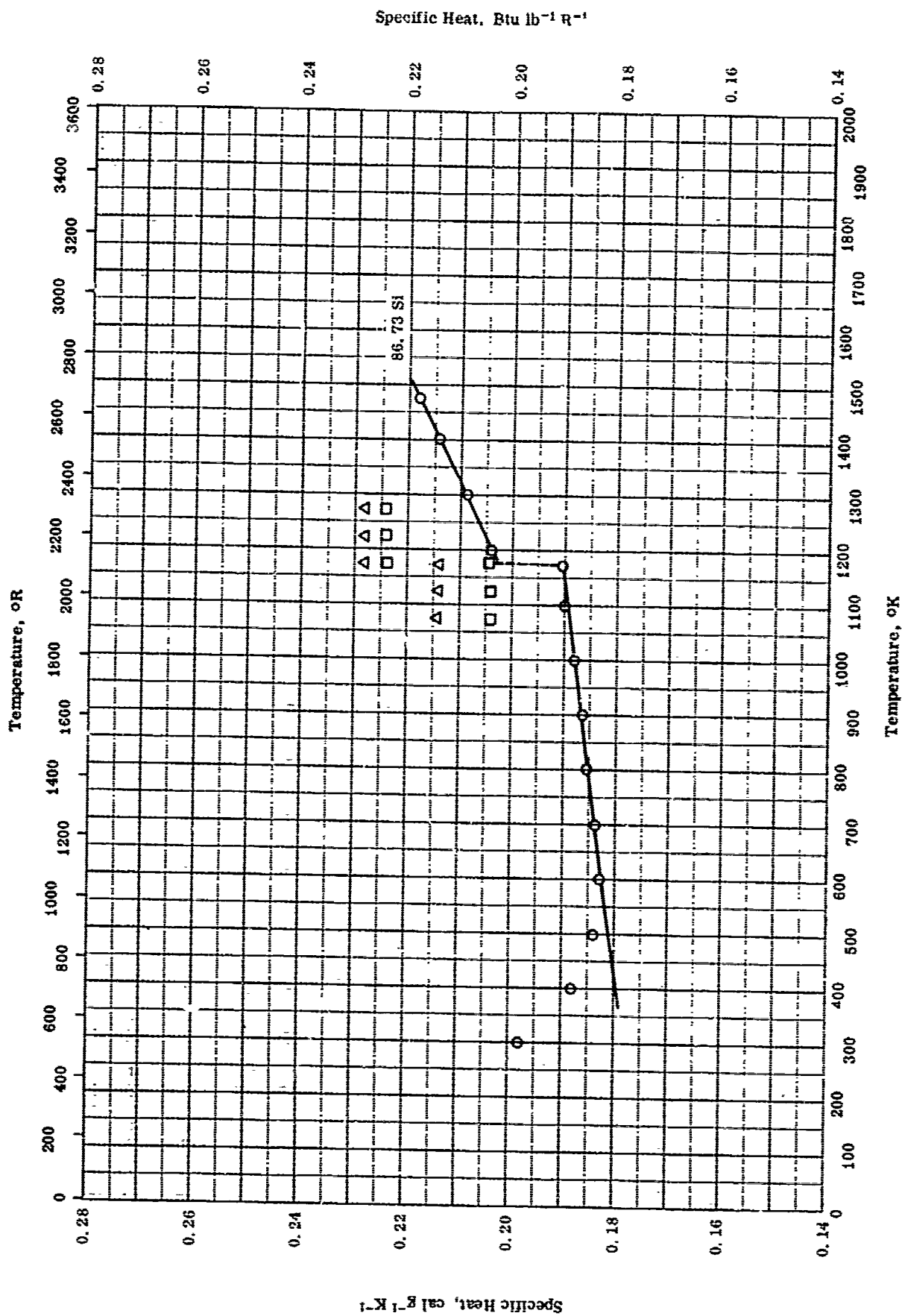


DENSITY -- SILICON + GERMANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| ○ | 54-22 | 298 | | 27-76 Ge. | Author claims accuracy within a few percent. |
| □ | 55-26 | 298 | | 22-72 Ge; from zone-melted Ge and hyper-pure Si; alloy homogeneous. | Prepared by isothermal solidification. |

TPRC

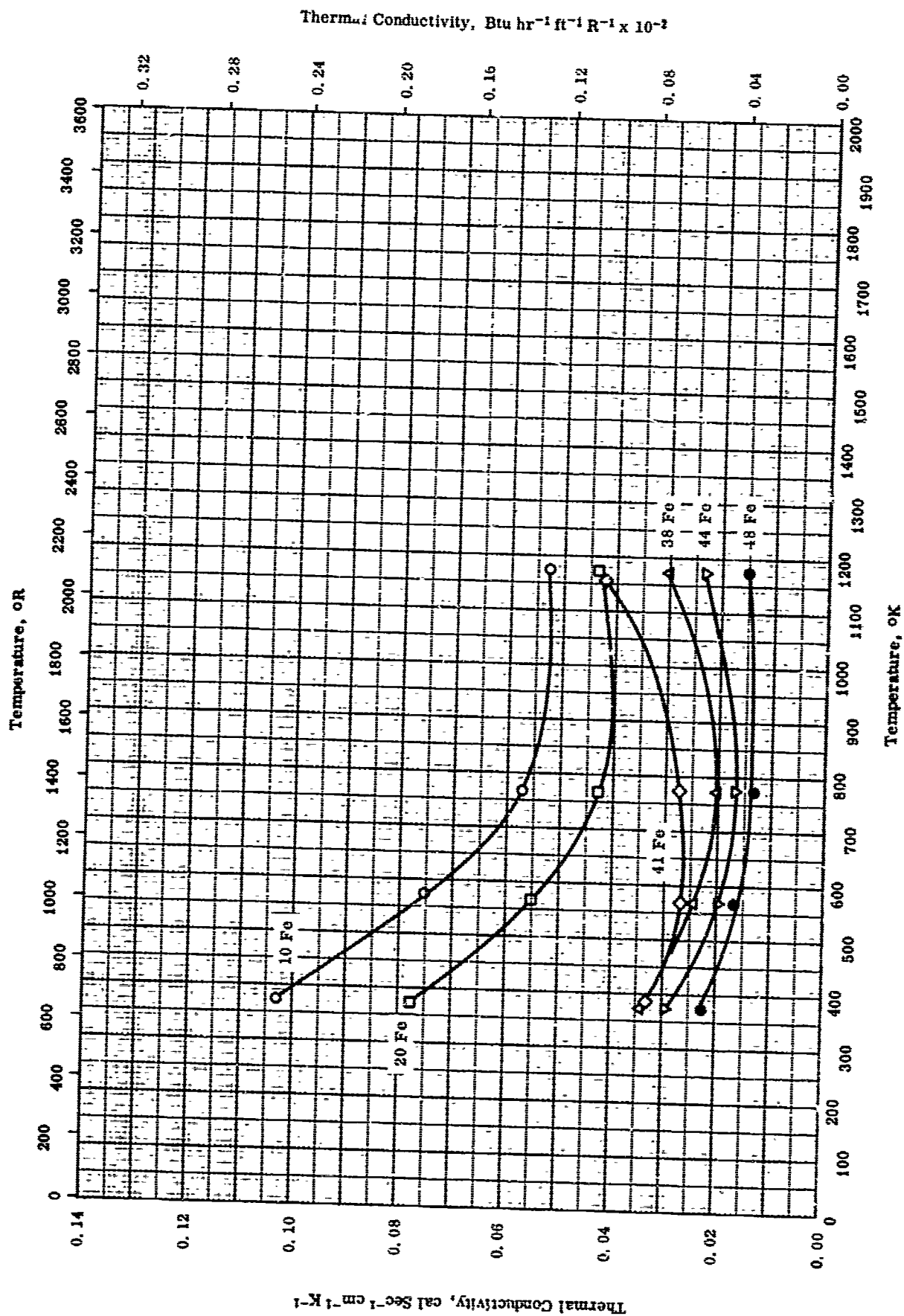


SPECIFIC HEAT -- SILICON + IRON

SPECIFIC HEAT -- SILICON + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--------------------------|
| ○ | 54-10 | 300-1473 | | 86.73 Si; prepared from Armco iron and 99.2 Si. | Annealed 3 hrs at 700 C. |
| □ | 54-10 | 1073-1273 | | 64.37 Si; raw materials same as above. | Same as above. |
| △ | 54-10 | 1073-1273 | | 53.4 Si; raw materials same as above. | Same as above. |



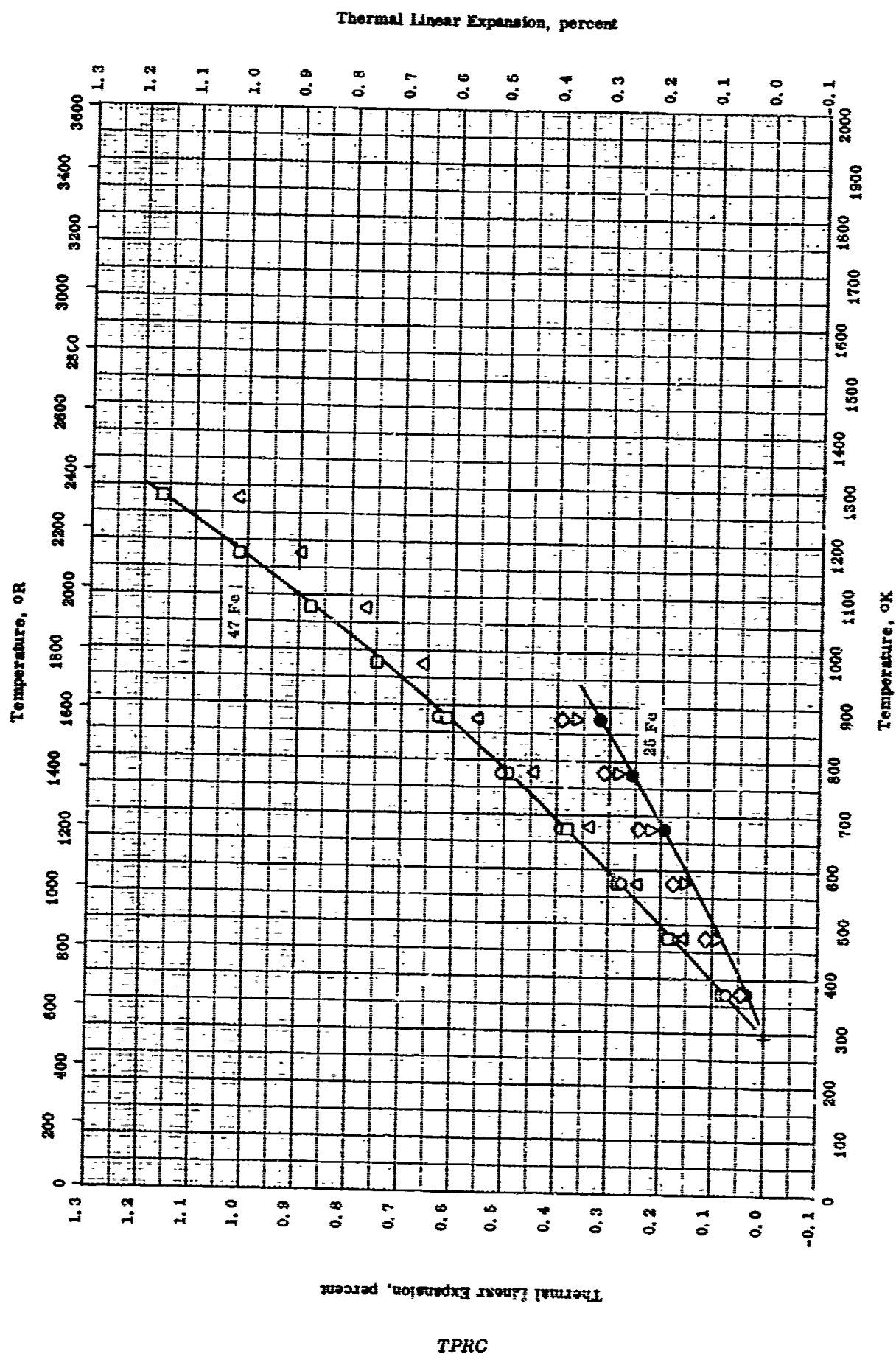
THERMAL CONDUCTIVITY -- SILICON + IRON

THERMAL CONDUCTIVITY -- SILICON + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 56-10 | 373-1173 | ± 7 | 90 Si and 10 Fe. | |
| □ | 56-10 | 373-1173 | ± 7 | 80 Si and 20 Fe. | |
| △ | 56-10 | 373-1173 | ± 7 | 62 Si and 38 Fe. | |
| ◇ | 56-10 | 373-1173 | ± 7 | 59 Si and 41 Fe. | |
| ▽ | 56-10 | 373-1173 | ± 7 | 55.5 Si and 44.5 Fe. | |
| ● | 56-10 | 373-1173 | ± 7 | 52.5 Si and 47.5 Fe. | |

TPRC



THERMAL LINEAR EXPANSION -- SILICON + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|----------------------|
| ○ | 56-40 | 373-873 | | 50.20 Si and 49.8 Fe. | Annealed. |
| □ | 56-40 | 373-1273 | | Lobatto; 53.38 Si and 46.62 Fe; α -phase. | Tempered from 950 C. |
| △ | 56-40 | 373-1273 | | Same as above; β -phase. | Annealed at 800 C. |
| ◇ | 56-40 | 373-873 | | 58.11 Si and 41.89 Fe. | Annealed. |
| ▽ | 56-40 | 373-873 | | 68.56 Si and 31.44 Fe. | Same as above. |
| ● | 56-40 | 373-873 | | 75.03 Si and 24.97 Fe. | Same as above. |

PROPERTIES OF SILVER + ALUMINUM

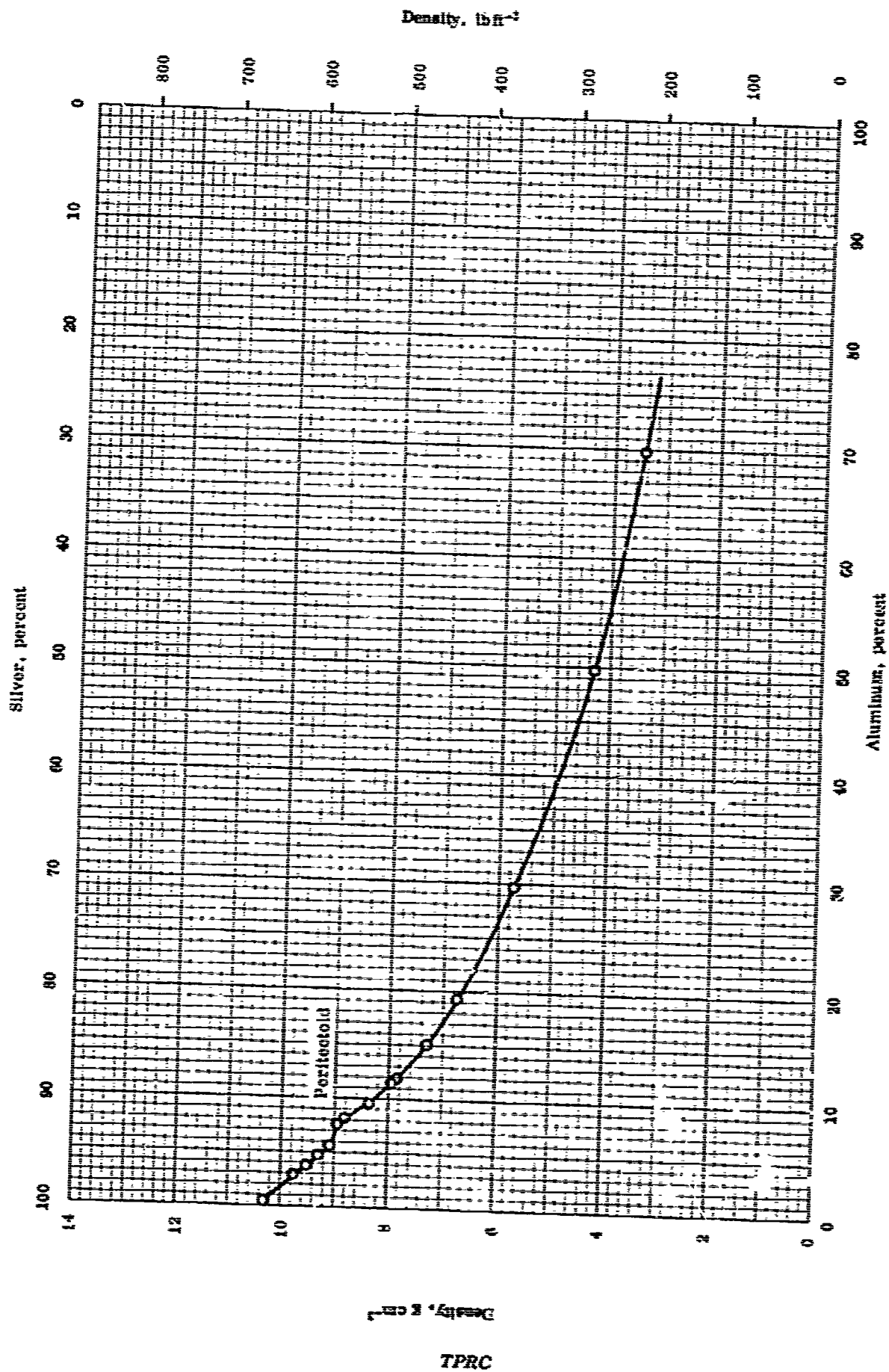
REPORTED VALUES

| | | |
|----------------------|---------------------|----------------------|
| Density: | See figure | |
| Heat of Sublimation: | cal g ⁻¹ | Btu lb ⁻¹ |
| ○ 2 Al | 451 | 812 |
| □ 3 Al | 401 | 722 |
| △ 33.9 Al | 394 | 710 |

PROPERTIES OF SILVER + ALUMINUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 54-21 | 1013 | | 2 Al. | |
| □ | 54-21 | 1003 | | 3 Al. | |
| △ | 54-21 | 1048 | | 33.9 Al. | |



DENSITY -- SILVER + ALUMINUM

DENSITY -- SILVER + ALUMINUM

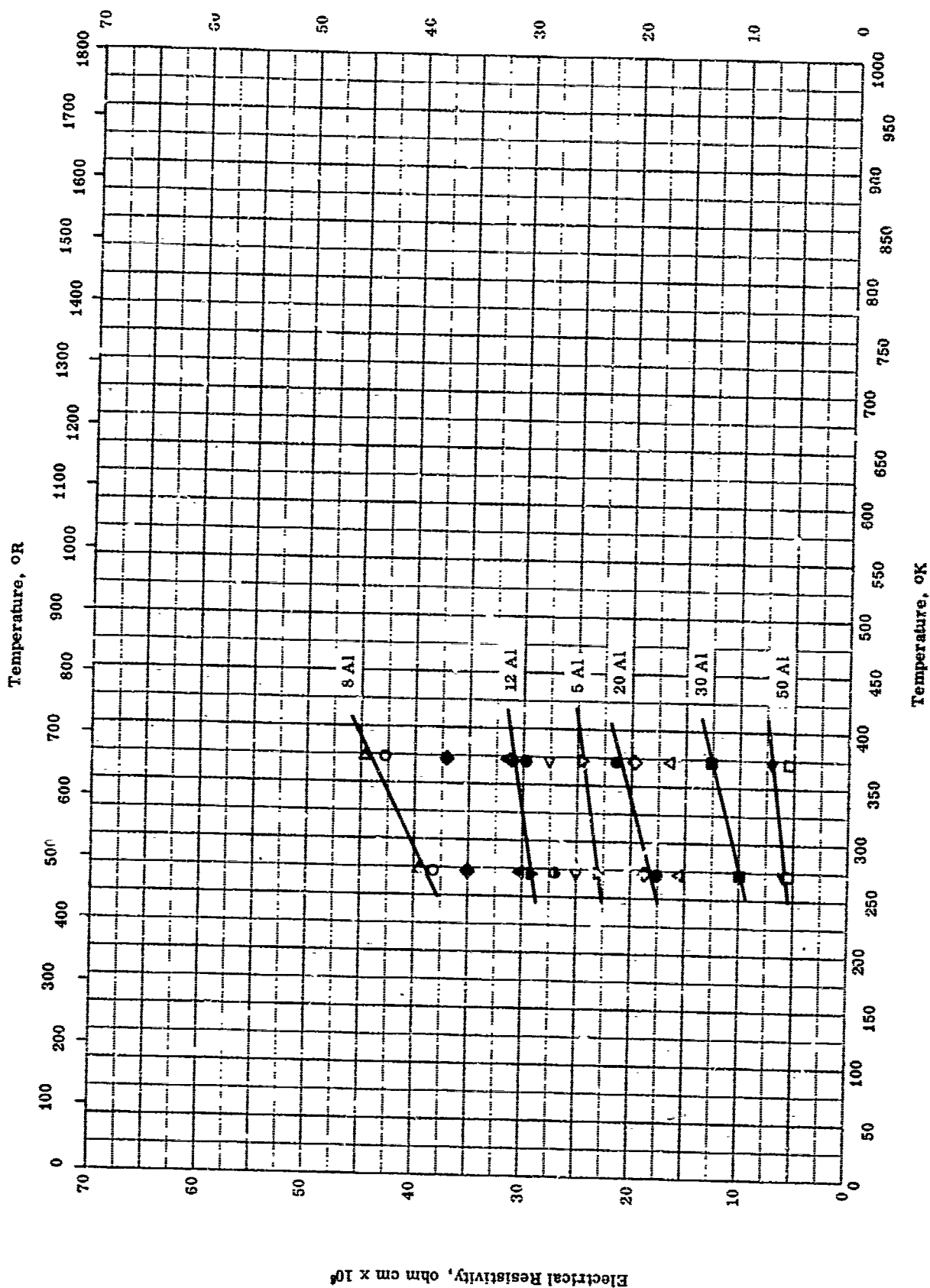
REFERENCE INFORMATION

| Sym Bol | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------------------|------------------|--|--|
| O | 43-1 | 298 | 0-70 Al; prepared from pure Ag and 99.99 Al. | Density by weight in air and in water. |

TPRC

Electrical Resistivity, ohm cm x 10⁶

433



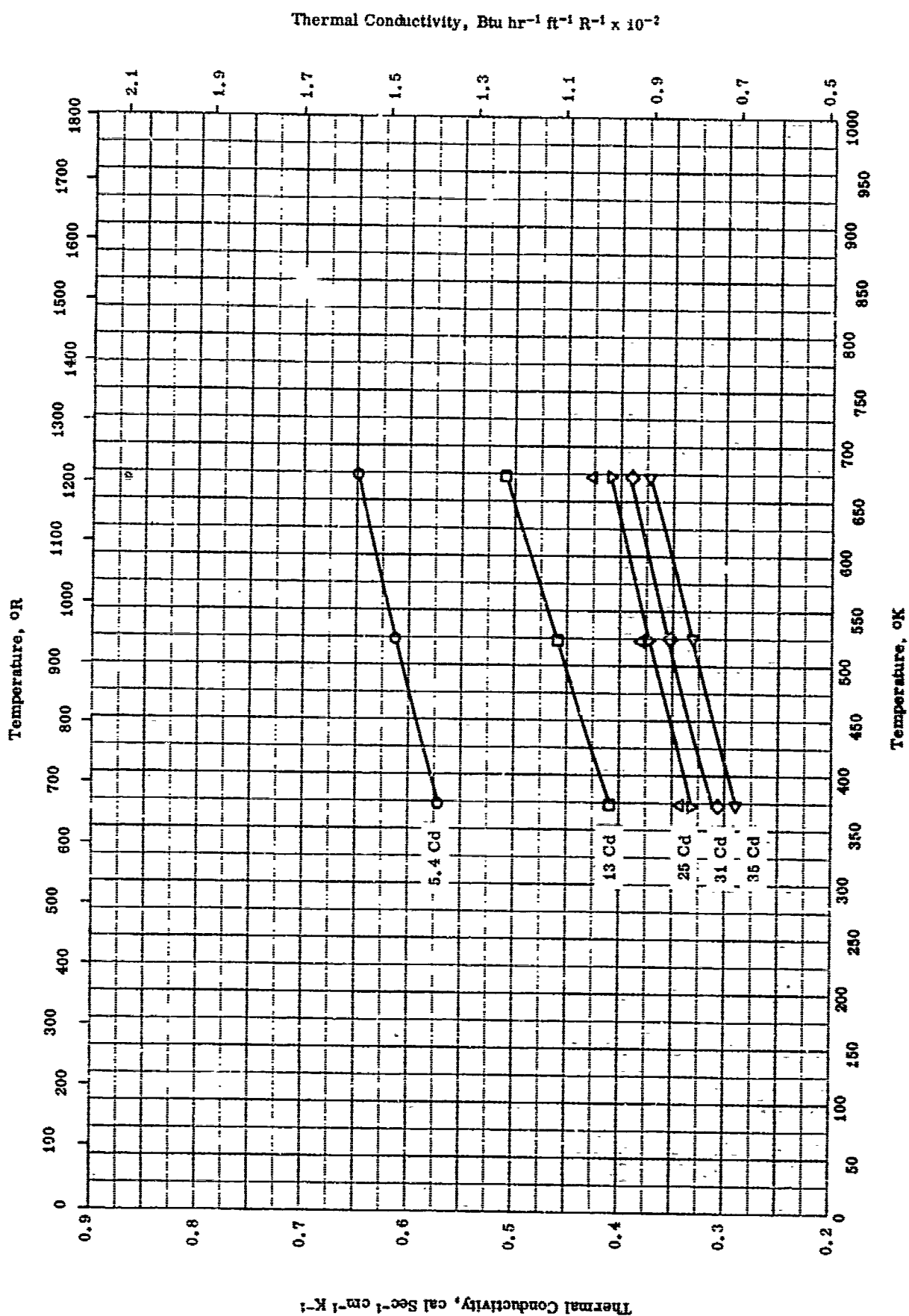
ELECTRICAL RESISTIVITY -- SILVER + ALUMINUM

ELECTRICAL RESISTIVITY -- SILVER + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---------|
| □ | 43-1 | 273-373 | | 95.50 Ag and 0.50 Al; density 643 lb ft ⁻³ . | |
| △ | 43-1 | 273-373 | | 97.00 Ag and 3.00 Al; density 608 lb ft ⁻³ . | |
| ◇ | 43-1 | 273-373 | | 96.11 Ag and 3.89 Al; density 592 lb ft ⁻³ . | |
| ▽ | 43-1 | 273-373 | | 95.08 Ag and 4.92 Al; density 580 lb ft ⁻³ . | |
| ◁ | 43-1 | 273-373 | | 94.29 Ag and 5.71 Al; density 567 lb ft ⁻³ . | |
| ▷ | 43-1 | 273-373 | | 92.30 Ag and 7.70 Al; density 588 lb ft ⁻³ . | |
| ○ | 43-1 | 273-373 | | 91.75 Ag and 8.25 Al; density 540 lb ft ⁻³ . | |
| ◆ | 43-1 | 273-373 | | 90.40 Ag and 9.60 Al; density 524 lb ft ⁻³ . | |
| ▲ | 43-1 | 273-373 | | 88.50 Ag and 11.50 Al; density 497 lb ft ⁻³ . | |
| ▼ | 43-1 | 273-373 | | 87.96 Ag and 12.04 Al; density 490 lb ft ⁻³ . | |
| ● | 43-1 | 273-373 | | 84.74 Ag and 15.26 Al; density 455 lb ft ⁻³ . | |
| ● | 43-1 | 273-373 | | 80.60 Ag and 19.40 Al; density 421 lb ft ⁻³ . | |
| ■ | 43-1 | 273-373 | | 70.23 Ag and 29.77 Al; density 357 lb ft ⁻³ . | |
| ◀ | 43-1 | 273-373 | | 50.19 Ag and 49.81 Al; density 268 lb ft ⁻³ . | |

TPRC

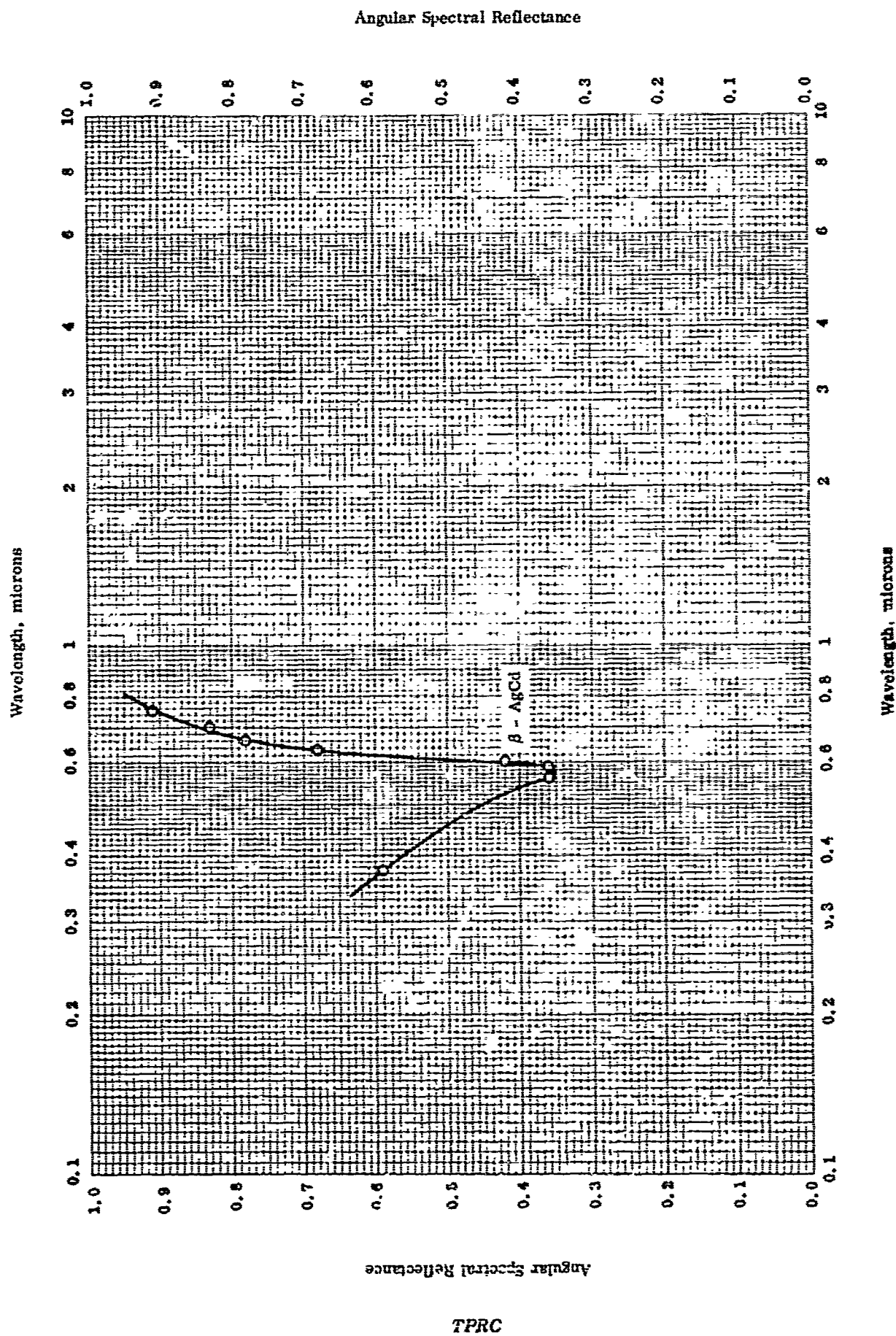


THERMAL CONDUCTIVITY -- SILVER + CADMIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---------------------------------------|
| ○ | 51-5 | 373-673 | | 5.4 Cd. | |
| □ | 51-5 | 373-673 | | 12.9 Cd. | |
| △ | 51-5 | 373-673 | | 22.0 Cd. | Cross-section reduced 67% by rolling. |
| ▽ | 51-5 | 373-673 | | 24.5 Cd. | Same as above. |
| ◇ | 51-5 | 373-673 | | 31.8 Cd. | Cross-section reduced 67% by rolling. |
| ▽ | 51-5 | 373-673 | | 35.6 Cd. | |

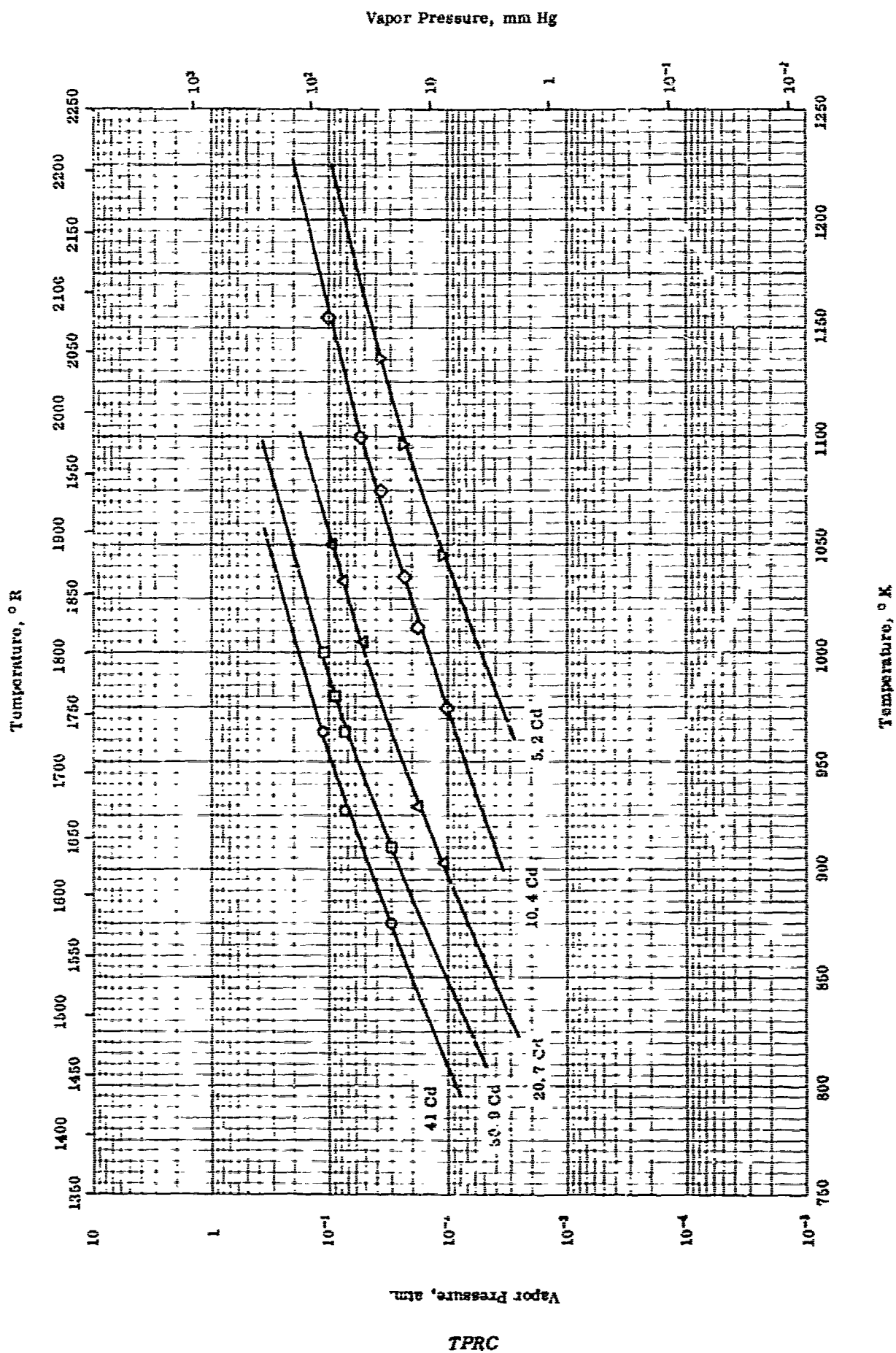
TPRC



ANGULAR SPECTRAL REFLECTANCE --- SILVER + CADMIUM

REFERENCE INFORMATION

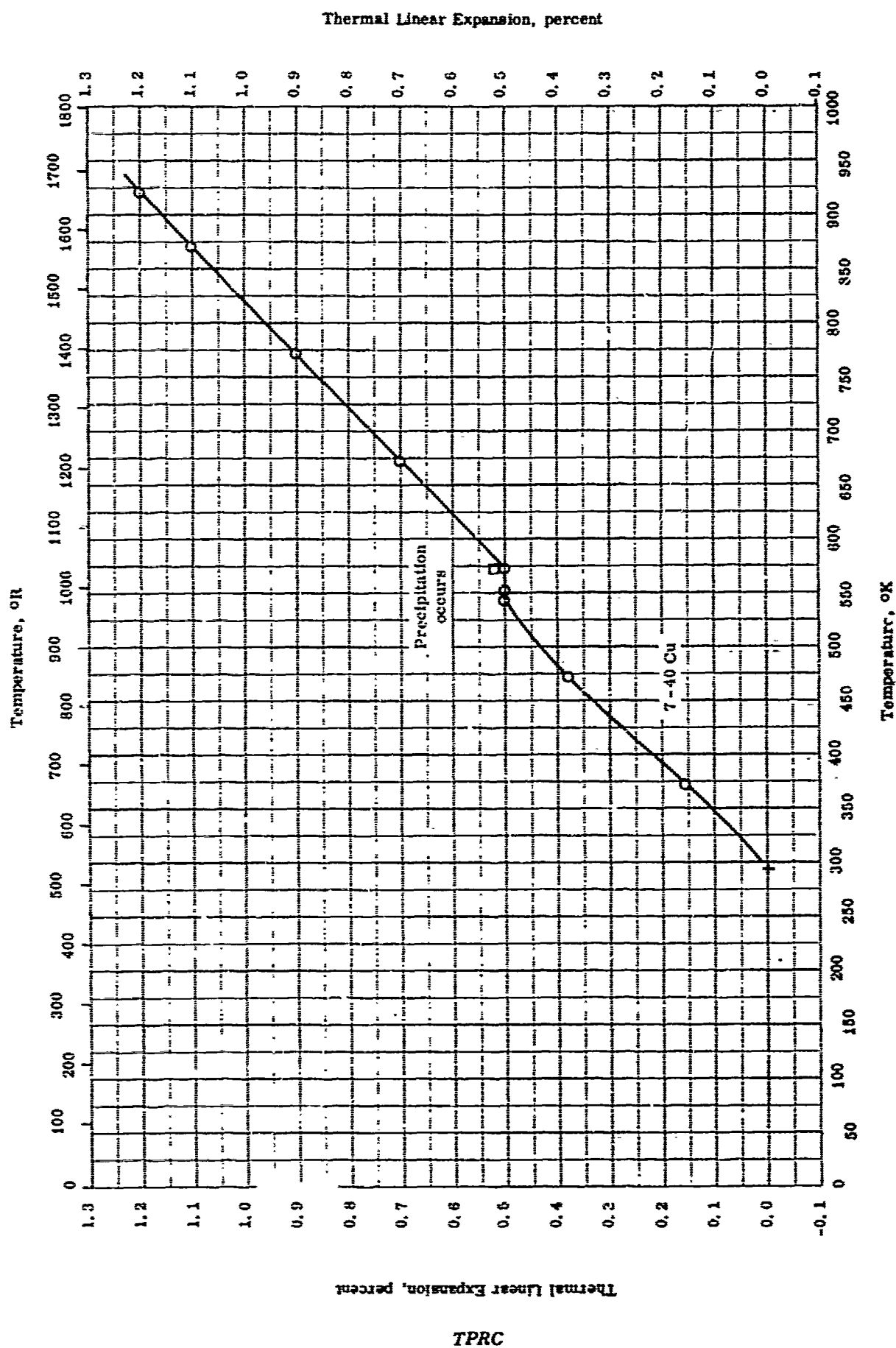
| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|-----------------|------------------------------|---|
| ○ | 61-24 | 298 | 0.375-0.75 | | β - AgCd; 2000 Å film. | Vacuum evaporated on glass; 45 degree illumination and 45 degree viewing; data extracted from smooth curve. |



VAPOR PRESSURE --- SILVER + CADMIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--------------------------------|---|
| ○ | 55-0 | 873-963 | | 41 Cd; $\alpha + \beta$ phase. | Data are pressure of Cd over the alloy. |
| □ | 55-0 | 911-998 | | 30.9 Cd; α -phase. | Same as above. |
| △ | 55-9 | 902-1051 | | 20.7 Cd; α -phase. | Same as above. |
| ◇ | 55-9 | 970-1160 | | 10.4 Cd; α -phase. | Same as above. |
| ▽ | 55-9 | 1040-1130 | | 5.2 Cd; α -phase. | Same as above. |

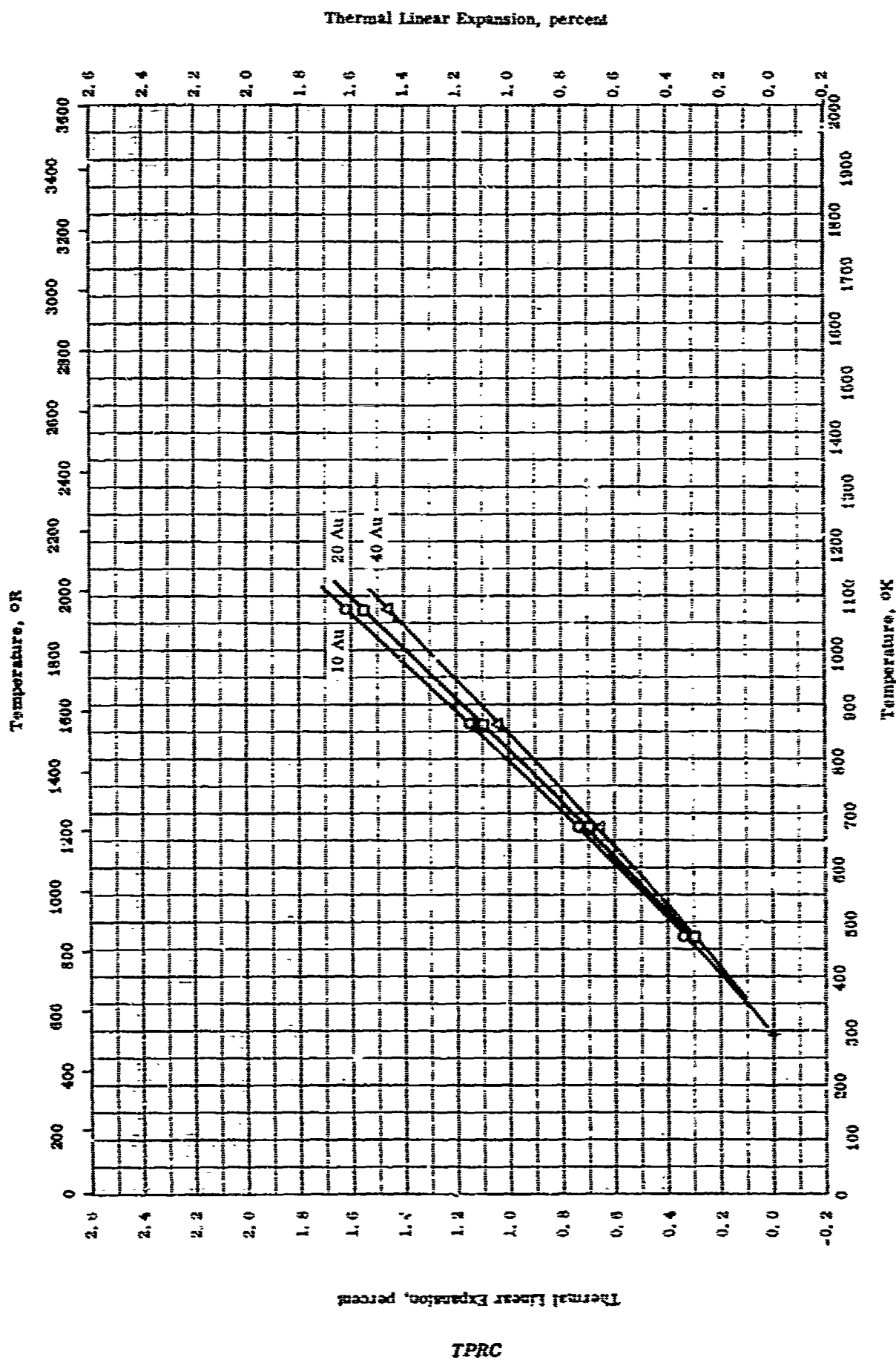


Thermal Linear Expansion -- SILVER + COPPER

THERMAL LINEAR EXPANSION -- SILVER + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|--|---|
| ○ | 40-12 | 293-923 | | U3 Ag and 7 Cu. | Homogenized; tested at 1.6 C min ⁻¹ . Cast; values of the 6 samples within ± 5% of plotted point. |
| □ | 35-30 | 293-573 | | 6 samples: | |
| | | | | (a) 78.5 Ag, 21.4 Cu, 0.027 As, and 0.010 P. | |
| | | | | (b) 76.7 Ag, 23.2 Cu, 0.027 As, and 0.012 P. | |
| | | | | (c) 74.3 Ag, 25.4 Cu, 0.017 As, and 0.010 P. | |
| | | | | (d) 71.3 Ag, 28.0 Cu, 0.021 As, and 0.012 P. | |
| | | | | (e) 69.2 Ag, 30.2 Cu, 0.027 As, and 0.012 P. | |
| | | | | (f) 68.6 Ag, 40.3 Cu, 0.021 As, and 0.012 P. | |



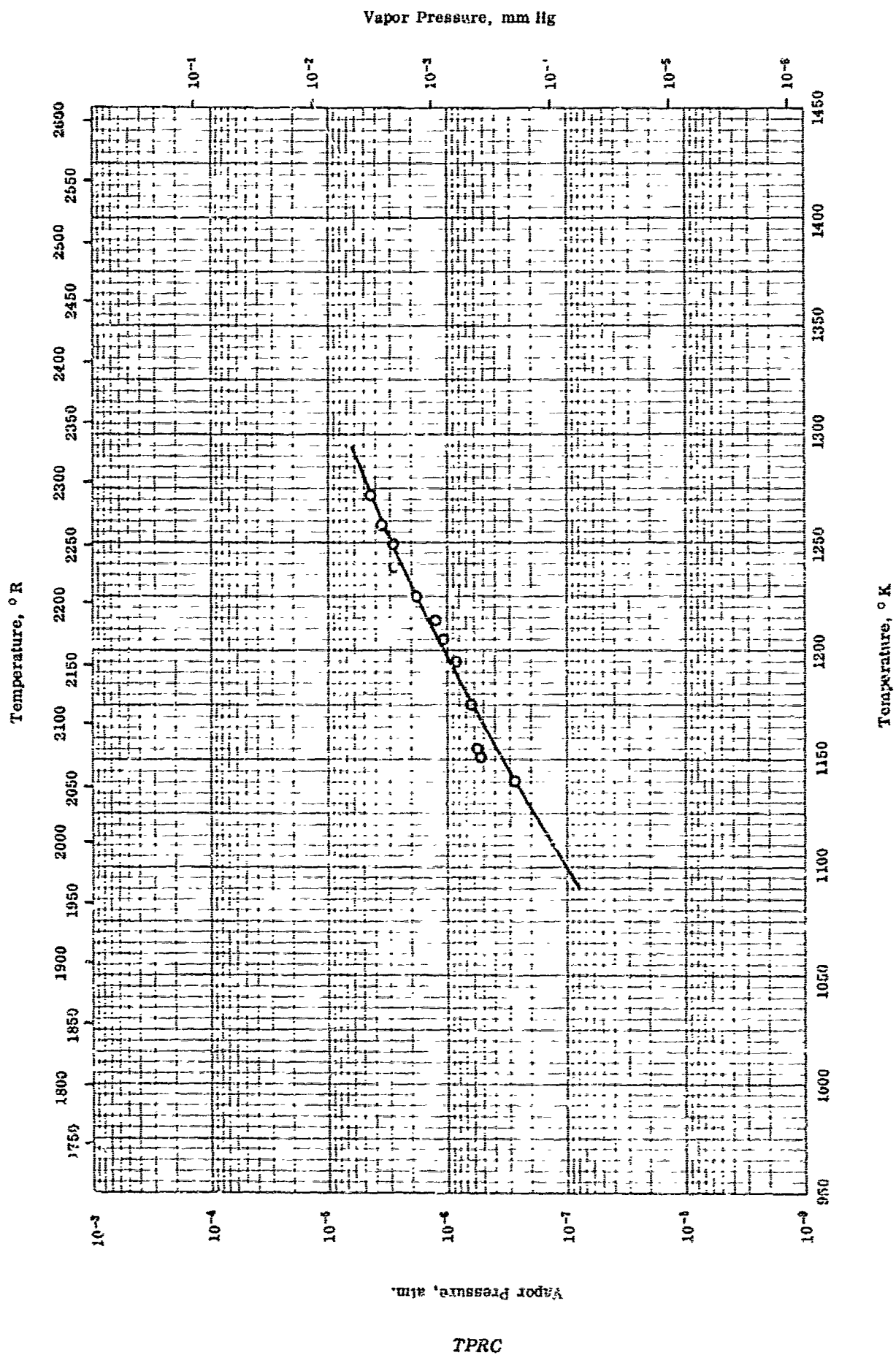
Thermal Linear Expansion - SILVER-GOLD

THERMAL LINEAR EXPANSION -- SILVER + GOLD

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------------|
| ○ | 51-17 | 293-1073 | | 90 Ag and 10 Au. | Homogenized. |
| □ | 51-17 | 293-1073 | | 80 Ag and 20 Au. | Same as above. |
| △ | 51-17 | 293-1073 | | 60 Ag and 40 Au. | Same as above. |

TPRC



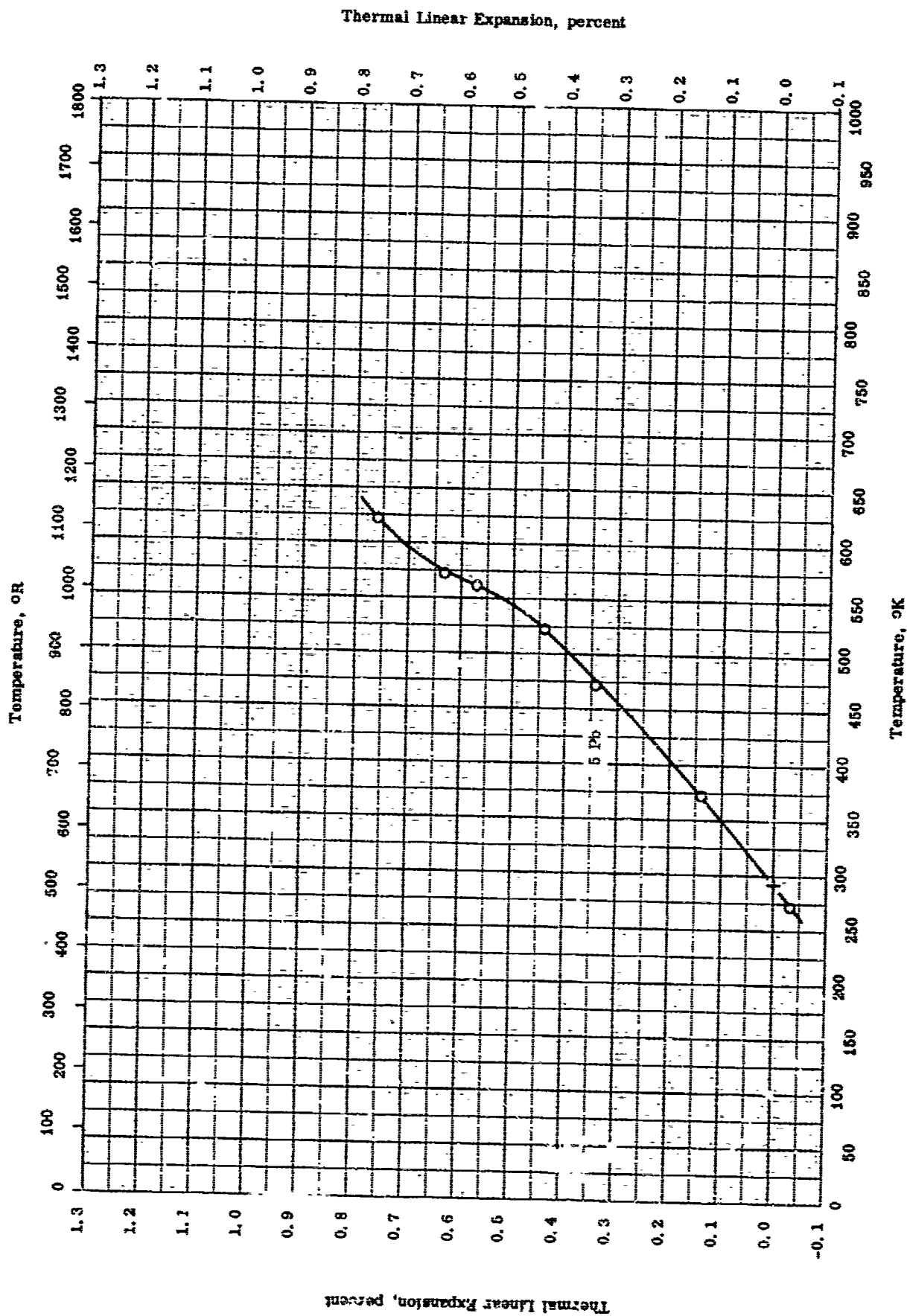
VAPOR PRESSURE -- SILVER + GOLD

REFERENCE INFORMATION

| Sym No | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-------|-------------------|------------------|-----------------------|---------|
| 0 | 63-10 | 1141-1271 | | 65.3 Ag and 34.7 Au. | |

TPRC

THERMAL LINEAR EXPANSION -- SILVER + LEAD

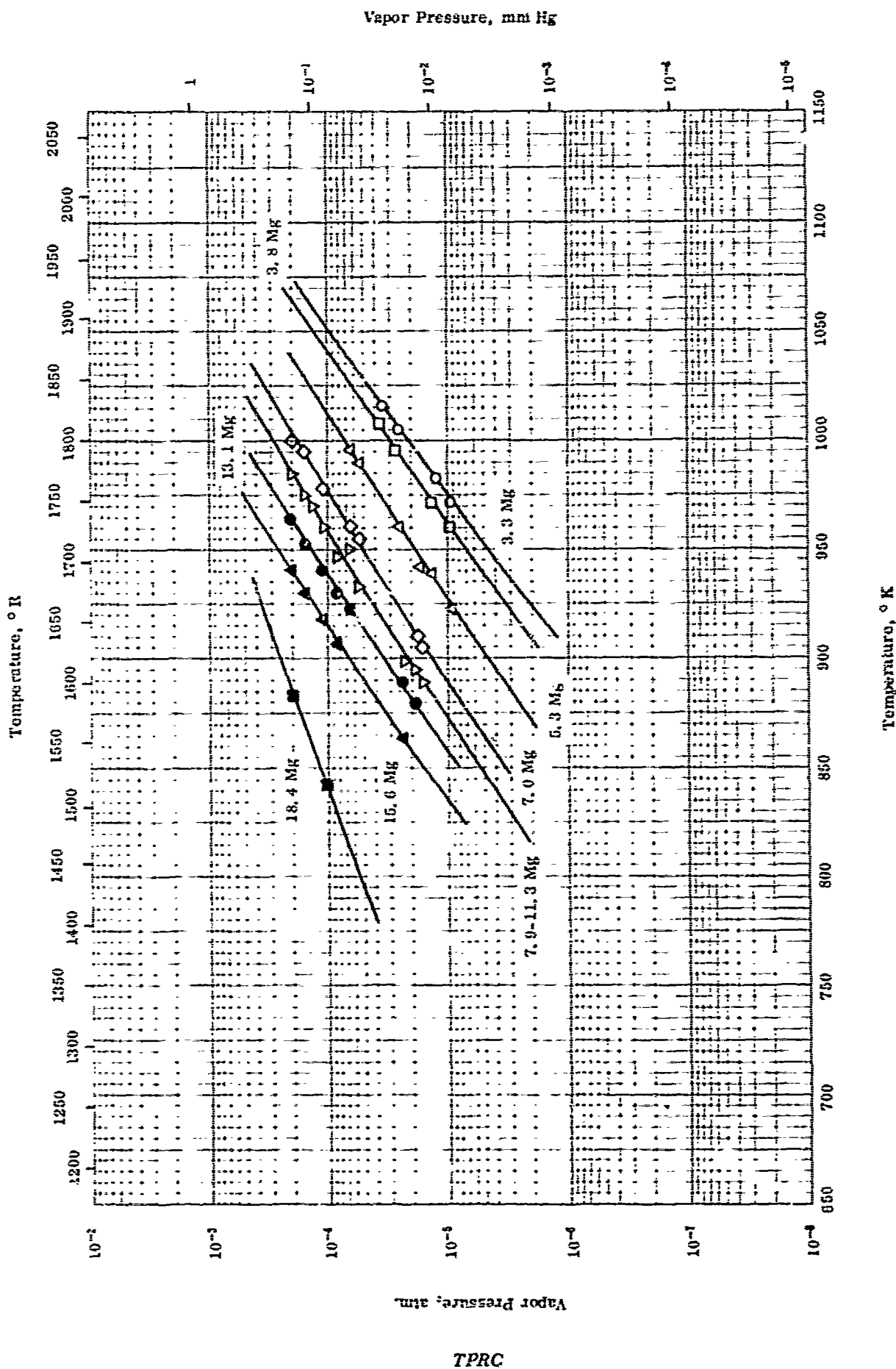


THERMAL LINEAR EXPANSION -- SILVER + LEAD

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| O | 49-12 | 273-623 | | 95 Ag and 5 Pb. | Homogenized; tested at 0.9 C min ⁻¹ . |

TPRC



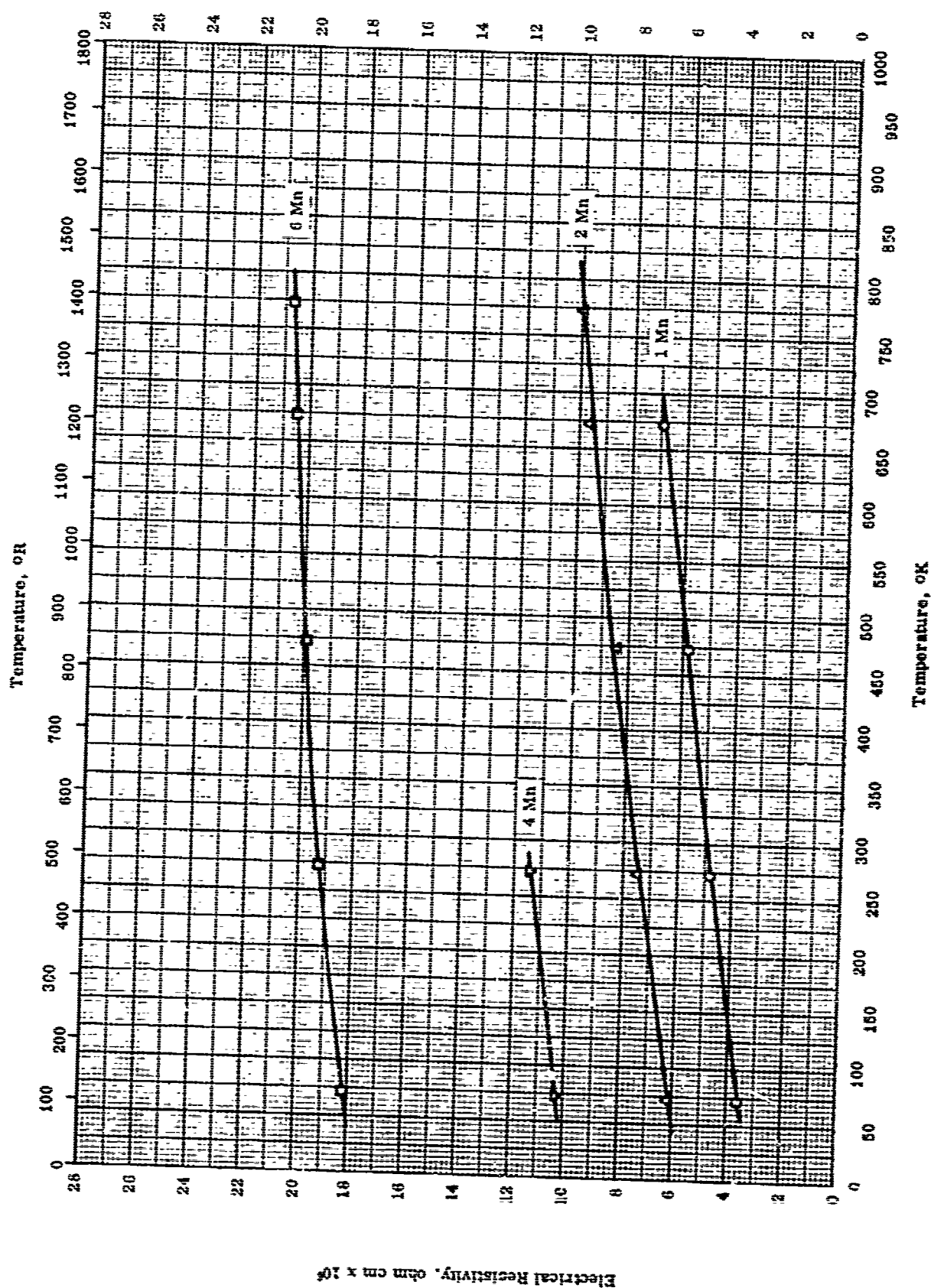
VAPOR PRESSURE -- SILVER + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ○ | 57-12 | 843-1023 | | 3.28 Mg; α phase. | Data are pressure of Mg vapor over the alloy. |
| □ | 57-12 | 843-1023 | | 3.83 Mg; α phase. | Same as above. |
| △ | 57-12 | 843-1023 | | 5.34 Mg; α phase. | Same as above. |
| ◇ | 57-12 | 843-1023 | | 6.99 Mg; α phase. | Same as above. |
| ▽ | 57-12 | 843-1023 | | 7.91 - 11.26 Mg; $\alpha + \beta$ phase (data constant over this compositional range). | Same as above. |
| ● | 57-12 | 843-1023 | | 13.07 Mg; β phase. | Same as above. |
| ▲ | 57-12 | 843-1023 | | 15.58 Mg; β phase. | Same as above. |
| ■ | 57-12 | 843-1023 | | 18.40 Mg; β phase. | Same as above. |

Electrical Resistivity, ohm cm $\times 10^6$

451



ELECTRICAL RESISTIVITY -- SILVER + MANGANESE

TPRC

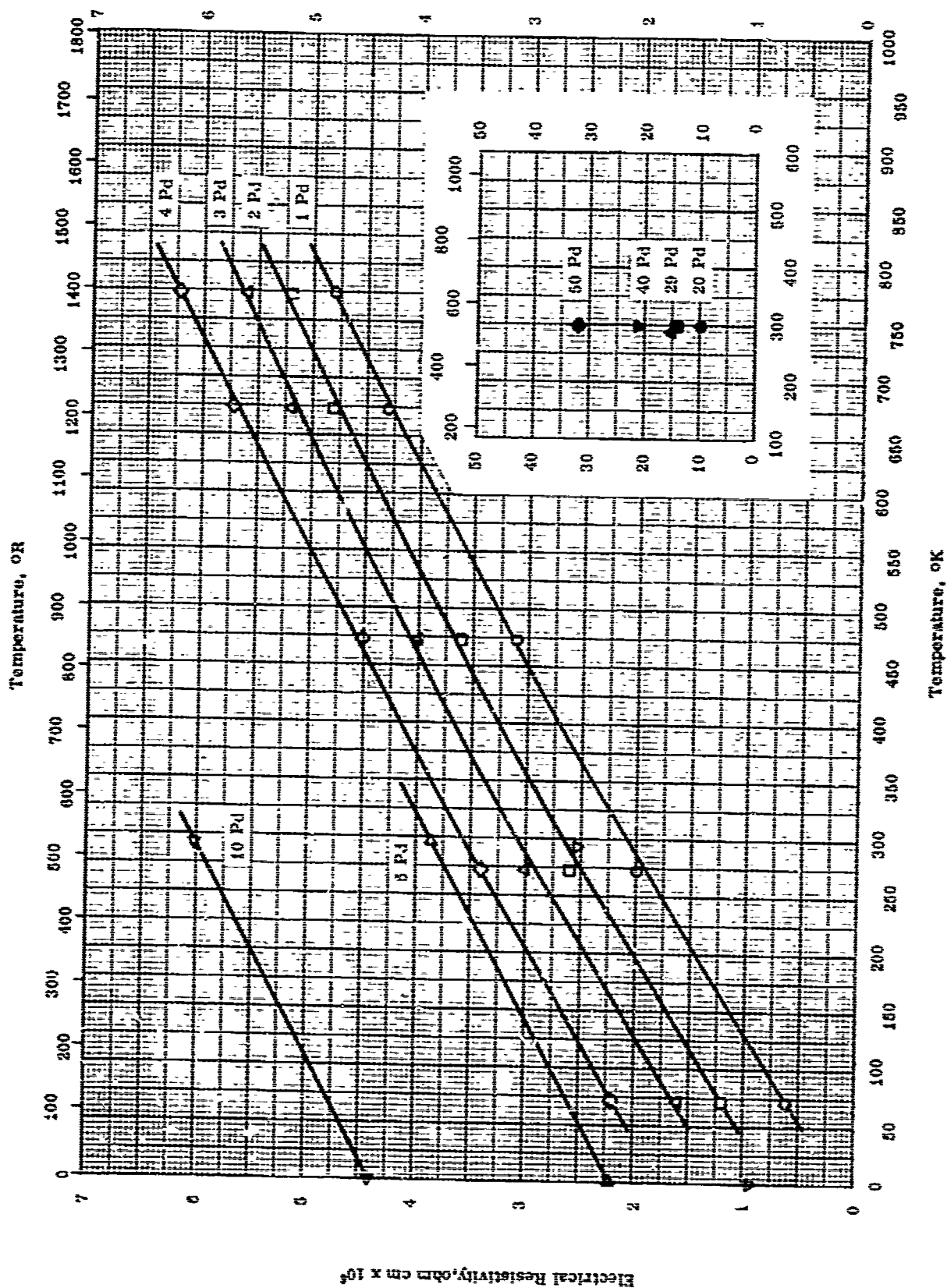
ELECTRICAL RESISTIVITY -- SILVER + MANGANESE

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---------------------------------------|---|
| ○ | 50-26 | 73-773 | | 1. 0 Mn; made from 99.99 pure metals. | Melted 100 C above MP, homogenized 24 hrs at 900 C, swaged to 0.030 in. dia., and annealed 1 hr at 100 C. |
| △ | 50-26 | 73-773 | | 2. 0 Mn; same as above. | Same as above. |
| □ | 50-26 | 73-773 | | 3. 0 Mn; same as above. | Same as above. |
| ▽ | 50-26 | 73-773 | | 4. 0 Mn; same as above. | Same as above. |

Electrical Resistivity, $\Omega\text{m cm} \times 10^6$

453



ELECTRICAL RESISTIVITY -- SILVER + PALLADIUM

TPRC

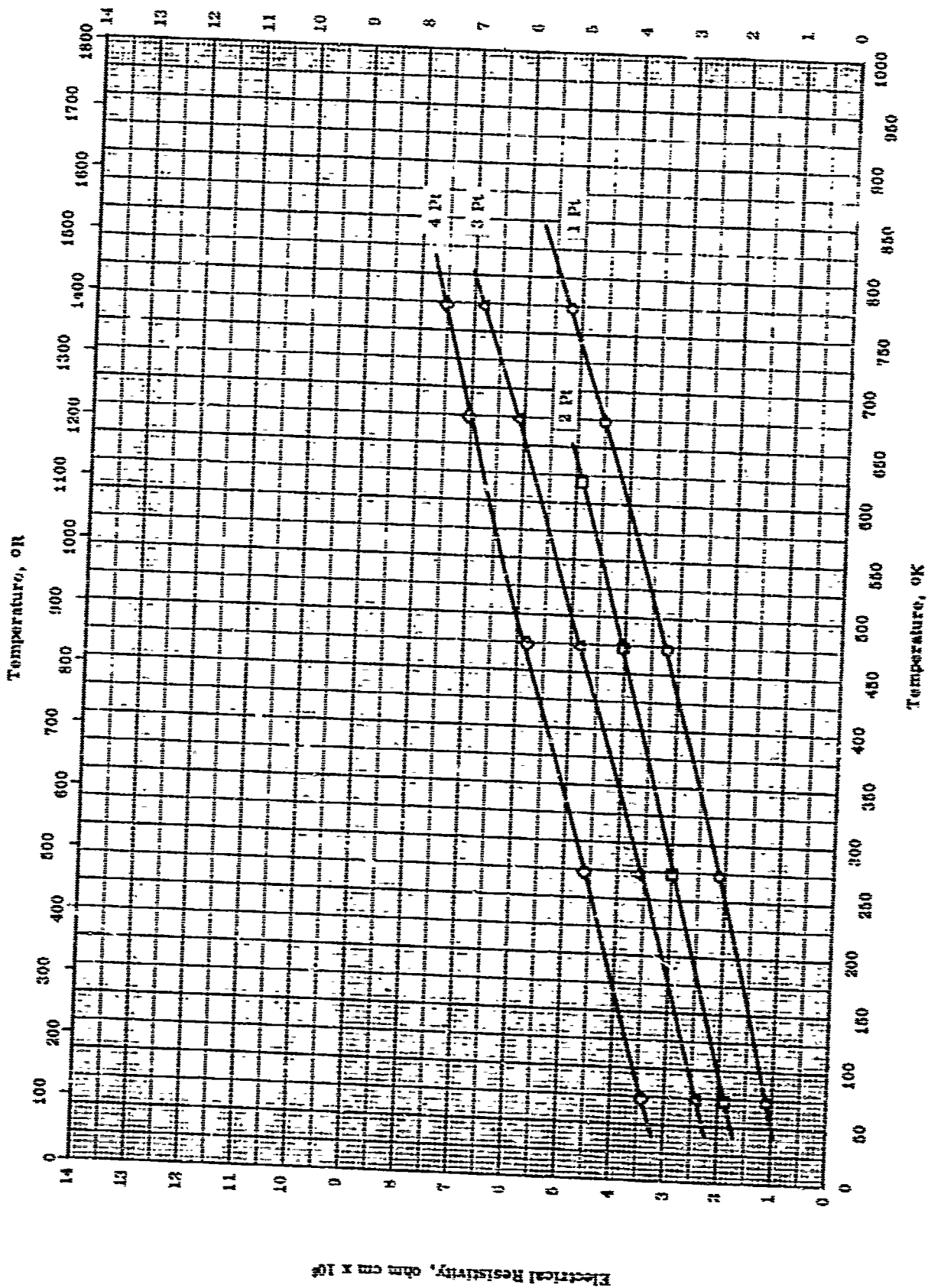
ELECTRICAL RESISTIVITY - SILVER + PALLADIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 50-20 | 70-773 | | 1.1 Pd. | Vac. melted from 99.99 pure metals 100 C above MP, homogenized 24 hrs at 900 C, swaged to 0.030 inch dia., and annealed 1 hr at 500 C. |
| □ | 50-20 | 73-773 | | 2.0 Pd. | Same as above. |
| △ | 50-20 | 73-773 | | 3.0 Pd. | Same as above. |
| ◇ | 50-20 | 73-773 | | 4.1 Pd. | Same as above. |
| ▽ | 50-23 | 0-293 | | 2.08 Pd. | Plotted data avg. of two samples (within $\pm 0.5\%$); sample A, wire annealed at 610 C; sample B, rod annealed at 610 C. |
| △ | 50-23 | 0-293 | | 6.00 Pd. | Same as above. |
| ▽ | 50-23 | 0-293 | | 0.9 Pd. | Same as above, except annealed at 650 C. |
| ● | 50-23 | 293 | | 20.08 Pd; wire. | Annealed at 650 C. |
| ■ | 50-23 | 293 | | 20.02 Pd; wire. | Same as above. |
| ▲ | 50-23 | 293 | | Same as above; rod. | Annealed at 800 C. |
| ▼ | 50-23 | 293 | | 40 Pd. | Two samples: |
| ● | 50-23 | 293 | | 50 Pd. | (a) Wire annealed at 880 C and 500 C. (b) Rod annealed at 880 C. Same as above. |

Electrical Resistivity, ohm cm x 10⁶

455



ELECTRICAL RESISTIVITY -- SILVER + PLATINUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 56-26 | 73-773 | | 1. 0 Pt; prepared from 99.99 pure metals. | Vacuum-melted at 100 C above MP, homogenized 24 hrs at 900 C, swaged to 0.030 in. dia., and annealed 1 hr at 500 C. |
| □ | 56-26 | 73-773 | | 2. 0 Pt; same as above. | Same as above. |
| △ | 56-26 | 73-773 | | 3. 0 Pt; same as above. | Same as above. |
| ◇ | 56-26 | 73-773 | | 4. 0 Pt; same as above. | Same as above. |

TPRC

PROPERTIES OF SILVER+ZINC

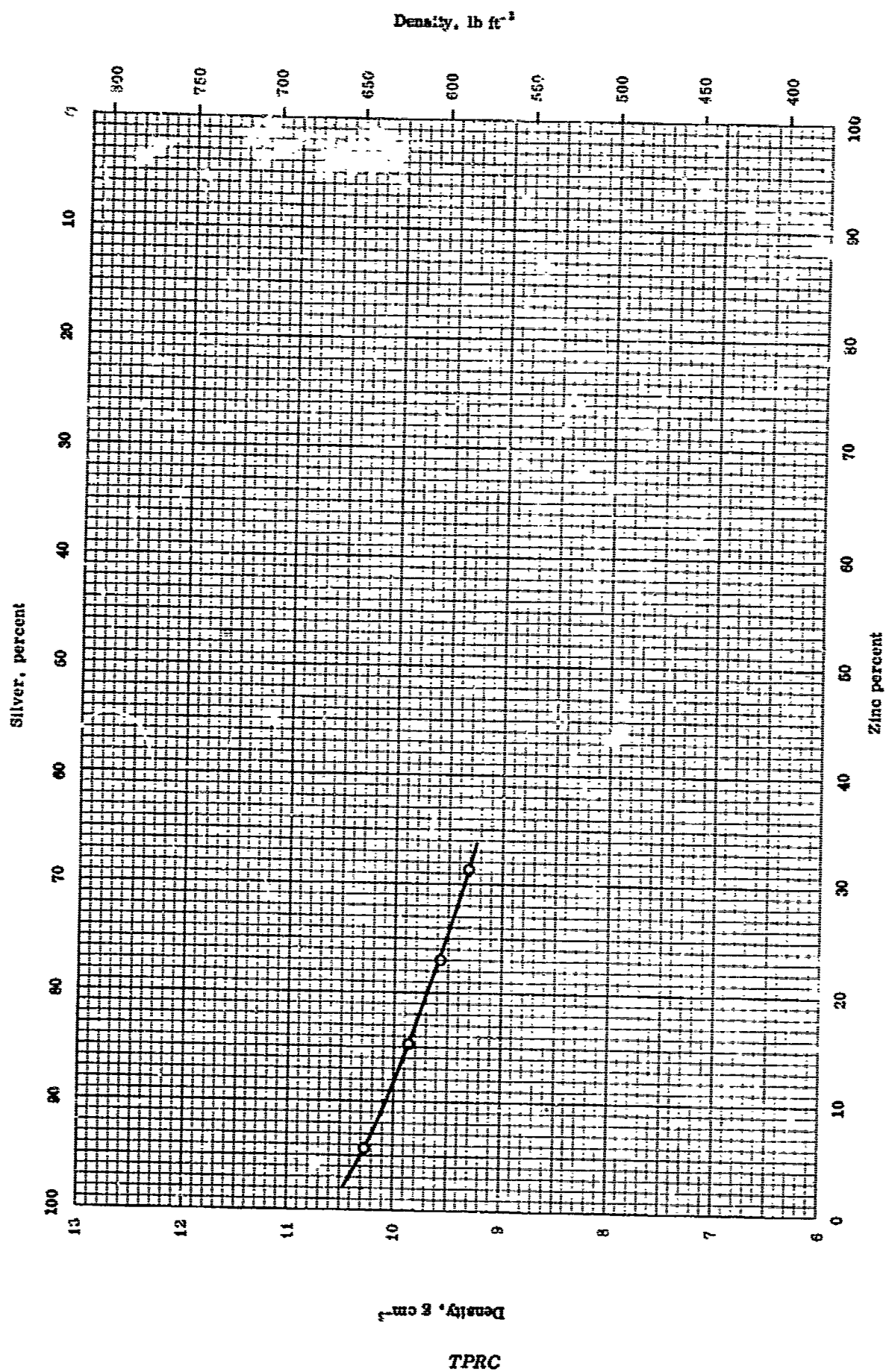
REPORTED VALUES

| | | |
|-----------------|---------------------|----------------------|
| Density: | See figure | |
| Melting Point: | K | R |
| ○ 49.5 Zn | 937 | 1687 |
| Heat of Fusion: | cal g ⁻¹ | Btu lb ⁻¹ |
| □ 49.5 Zn | 22.79 ± 0.98 | 41.02 ± 1.76 |

PROPERTIES OF SILVER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|----------------------------|--|
| ○ | 43-4 | 937 | | 49.5 Zn; γ - phase. | M. P. from break in time-temperature curve. |
| □ | 43-4 | 937 | | Same as above. | Δh_f from enthalpy differences of solid and liquid measurements. |



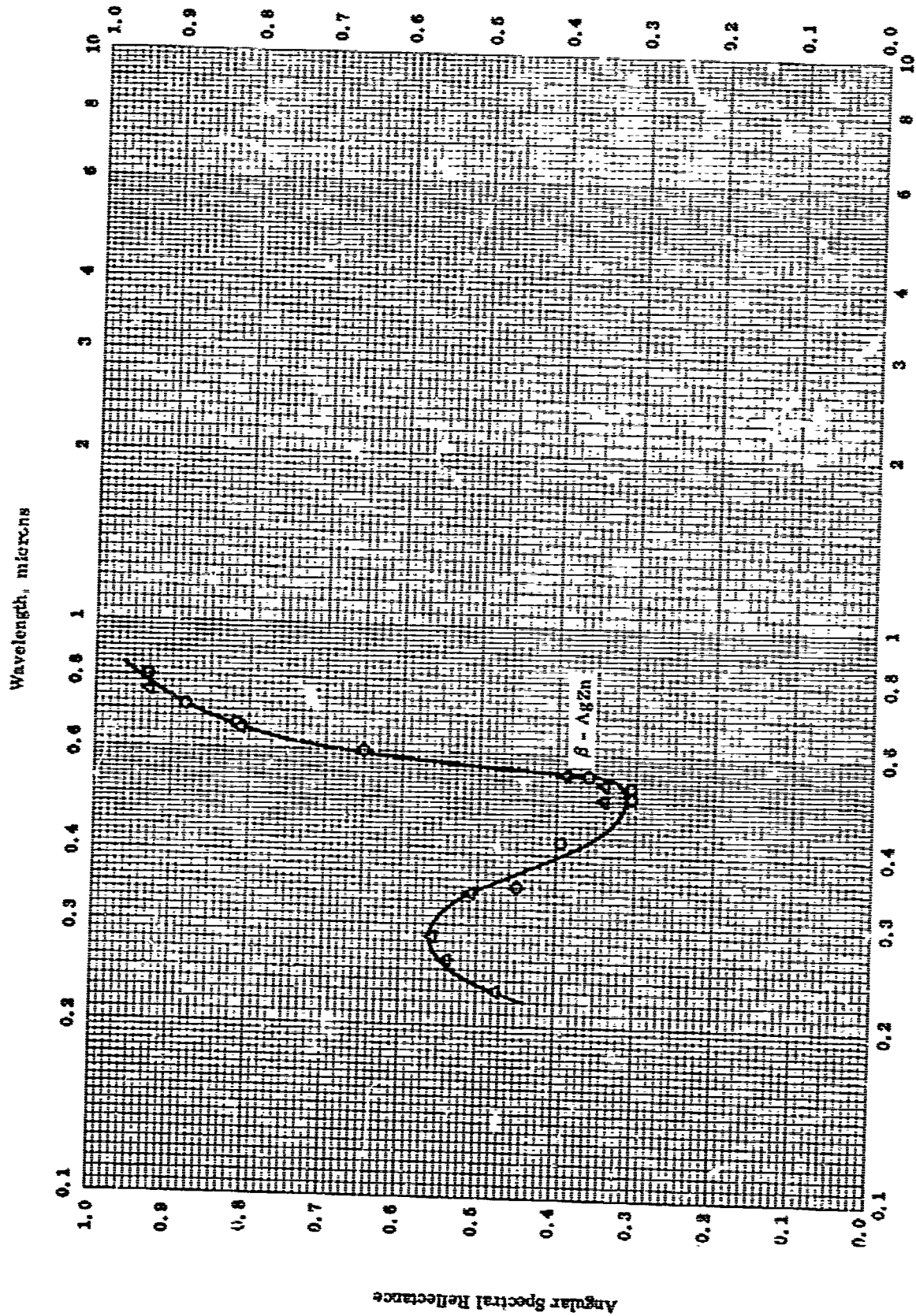
DENSITY -- SILVER + ZINC

DENSITY --- SILVER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|------------------------------------|--|
| O | 40-5 | 298 | | 5-31 Zn and negligible impurities. | Density by weight in air and in CCl ₄ |

TPRC



Wavelength, microns

ANGULAR SPECTRAL REFLECTANCE --- SILVER + ZINC

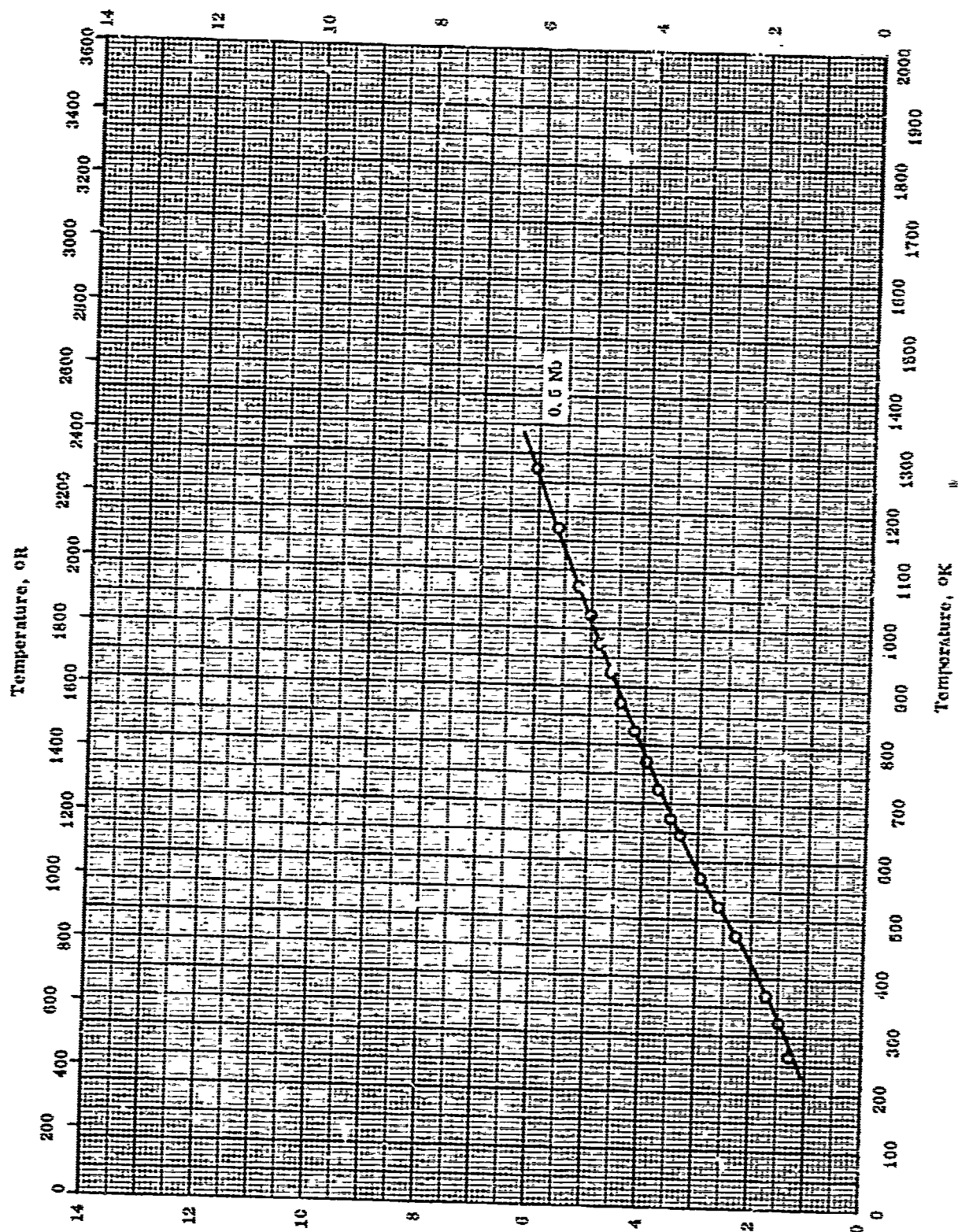
ANGULAR SPECTRAL REFLECTANCE -- SILVER + ZINC

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|----------|----------------------------|-----------------|------------------------------|---|
| O | 01-24 | 298 | 0.35-0.80 | | β - AgZn: 2600 Å film. | Vacuum evaporated on glass; 45 degree illumination and 45 degree viewing; data extracted from smooth curve. |
| Δ | 01-24 | 298 | 0.23-0.75 | | Same as above. | The above specimen, different run. |

Electrical Resistivity, ohm cm x 10⁶

453



ELECTRICAL RESISTIVITY -- TANTALUM + NIOBIUM

Electrical Resistivity, ohm cm x 10⁶

TPRC

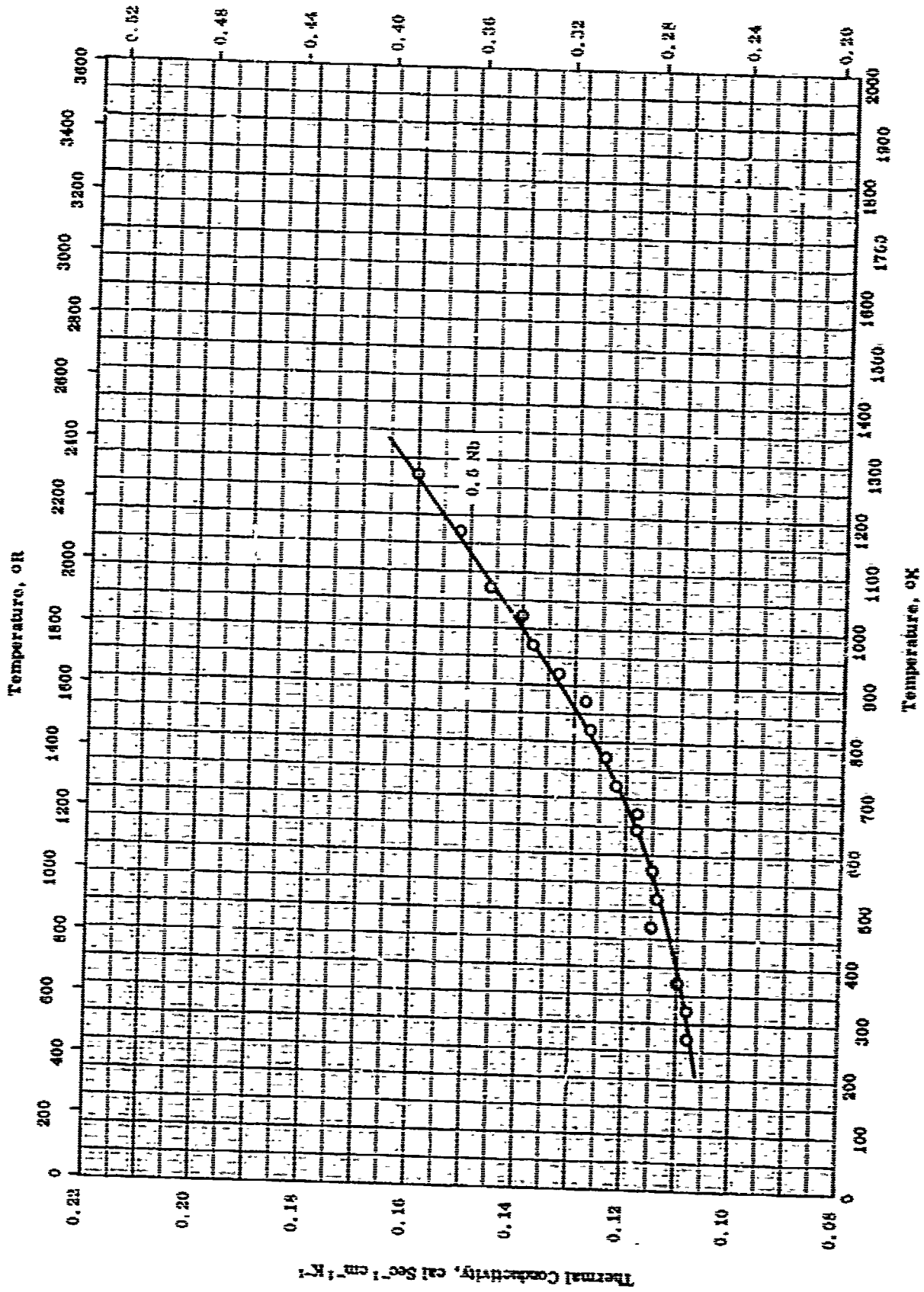
ELECTRICAL RESISTIVITY --- TANTALUM + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 63-10 | 273-1273 | | 0.5 Nb, 0.06 Fe, 0.008 Ti, 0.005 W, 0.003 Si, 0.002 C, and 0.001 Mo. | Sintered in vacuum for 5 hrs at 1723 K, the residual pressure in the furnace 10^{-3} mm Hg; finally sintered in vacuum of 10^{-6} mm Hg for 5 hrs at 2873 K; refined twice by zone-melting. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{K}^{-1} \times 10^{-2}$

465



THE THERMAL CONDUCTIVITY OF TANTALUM + NIOBIUM

TPRC

THERMAL CONDUCTIVITY -- TANTALUM + NIORIUM

REFERENCE INFORMATION

| Syr bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| O | 83-10 | 273-1273 | <5 | 0.5 Nb, 0.06 Fe, 0.008 Ti, 0.005 W, 0.003 Si, 0.002 C, and 0.001 Mo; prepared from electrolytic powders. | Pressed at 2.5 ton in ⁻² and double sintered at 1723 K for 5 hr and 2873 K in vacuum; forged and twice zone-melted. |

TPRC

PROPERTIES OF TANTALUM + TITANIUM

REPORTED VALUES

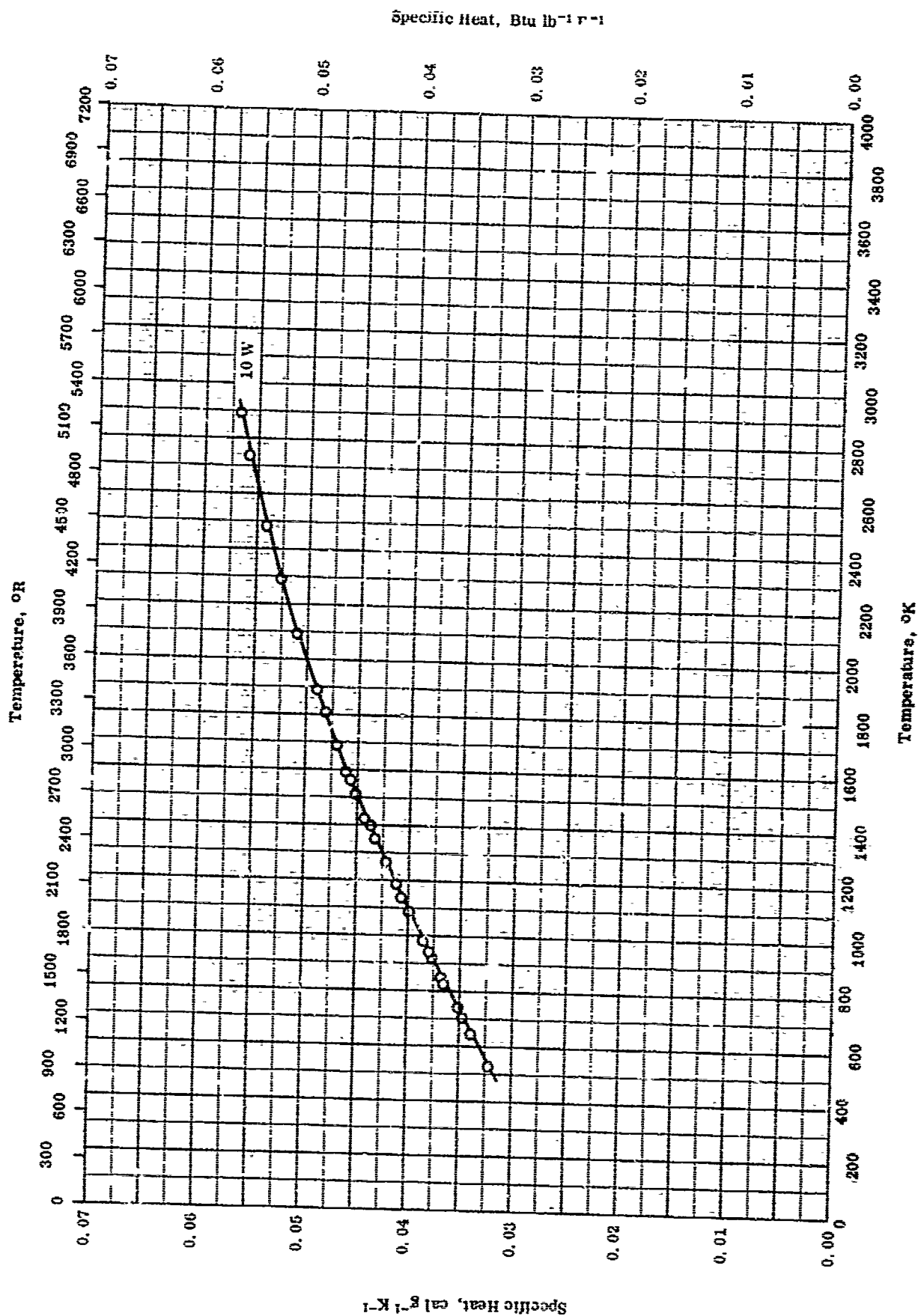
| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| ○ 40 Ti | 7.93 | 495.0 |
| □ 50 Ti | 7.07 | 441.0 |

PROPERTIES OF TANTALUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------------------------------------|
| ○ | 54-20 | 298 | | 40 Tl. | Density from weight in air and water. |
| □ | 54-20 | 298 | | 50 Tl. | Same as above. |

TPRC



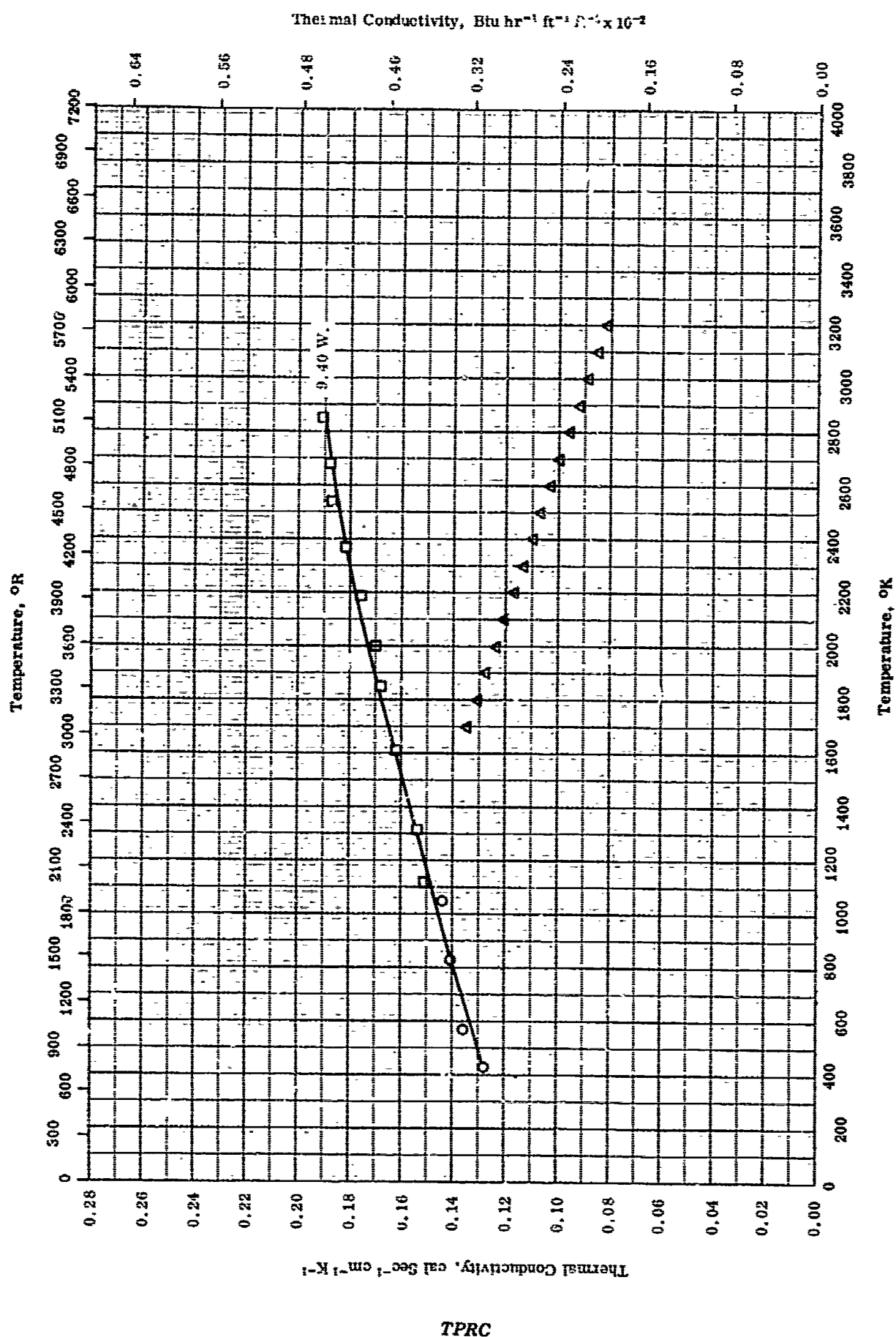
SPECIFIC HEAT -- TANTALUM + TUNGSTEN

SPECIFIC HEAT -- TANTALUM + TUNGSTEN

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|---------|
| O | 63-1 | 537-2890 | ± 5.0 | Ta - 10 W alloy; 3.50 W, 0.087 Nb, 0.02 Si; 0.02 Ti, 0.015 Mo; 0.005 Fe, 0.005 O ₂ , 0.003 N ₂ , and 0.0010 C; density 1035 lb ft ⁻³ . | |

TPRC



THERMAL CONDUCTIVITY -- TANTALUM + TUNGSTEN

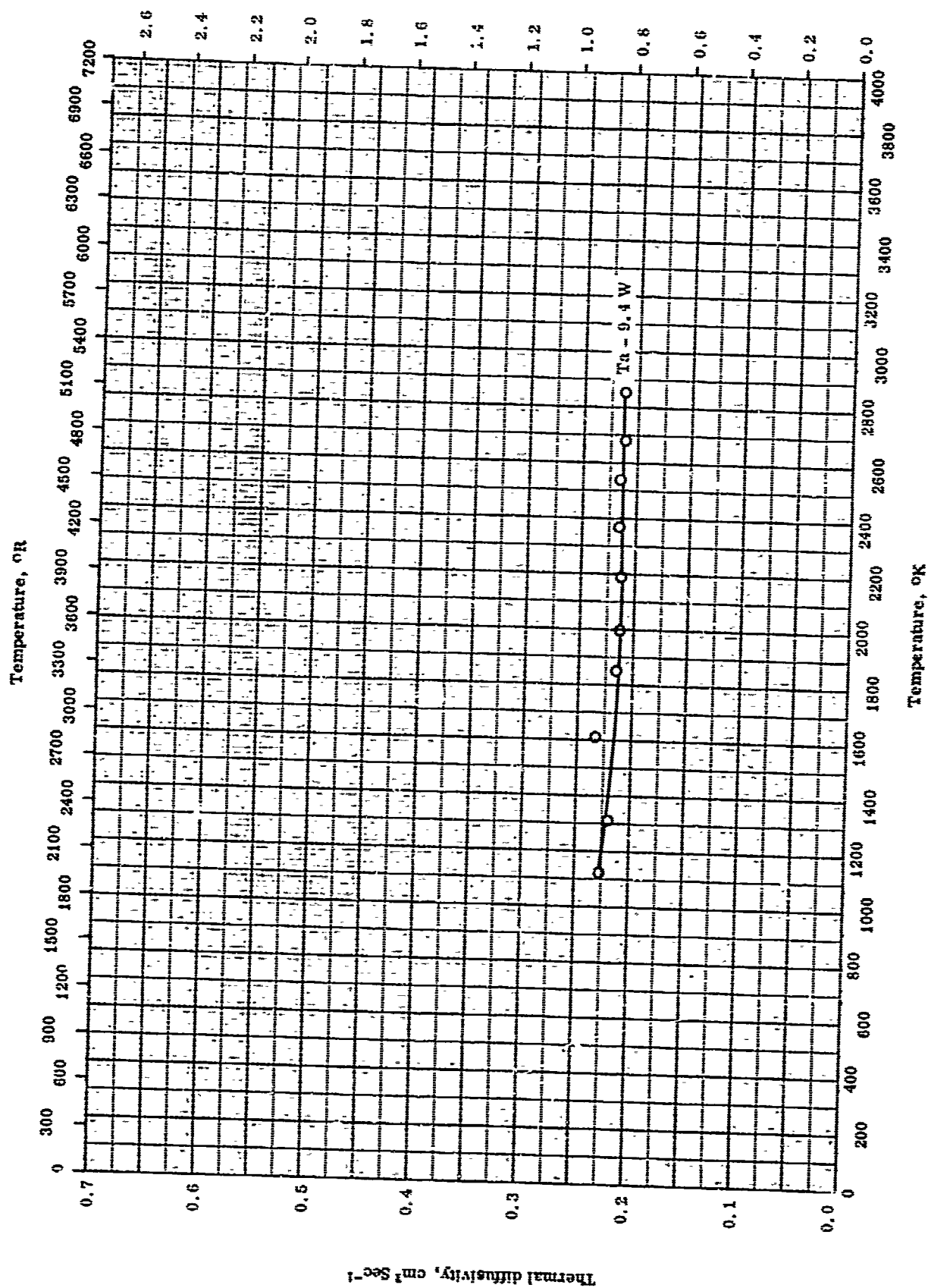
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| ○ | 63-1 | 435-1048 | ± 4 | 90.43 Ta, 2.40 W, 0.10 Nb, 0.02 Si, 0.02 Ti, 0.01 Mo, 0.01 Ni, 0.005 Fe, and 0.004 C. | End surface ground flat and parallel; measured in He atm. |
| □ | 63-1 | 1122-2850 | ± 4 | Same as above. | Same as above but a different method. |
| △ | 63-8 | 1700-3200 | | 9-11 W, 0.10 Nb, 0.10 Mo, 0.015 Si, 0.01 O, 0.01 Fe, 0.01 Ti, 0.005 C, 0.005 N, and 0.005 Ni. | |

TPRC

Thermal diffusivity, $\text{ft}^2 \text{hr}^{-1}$

473



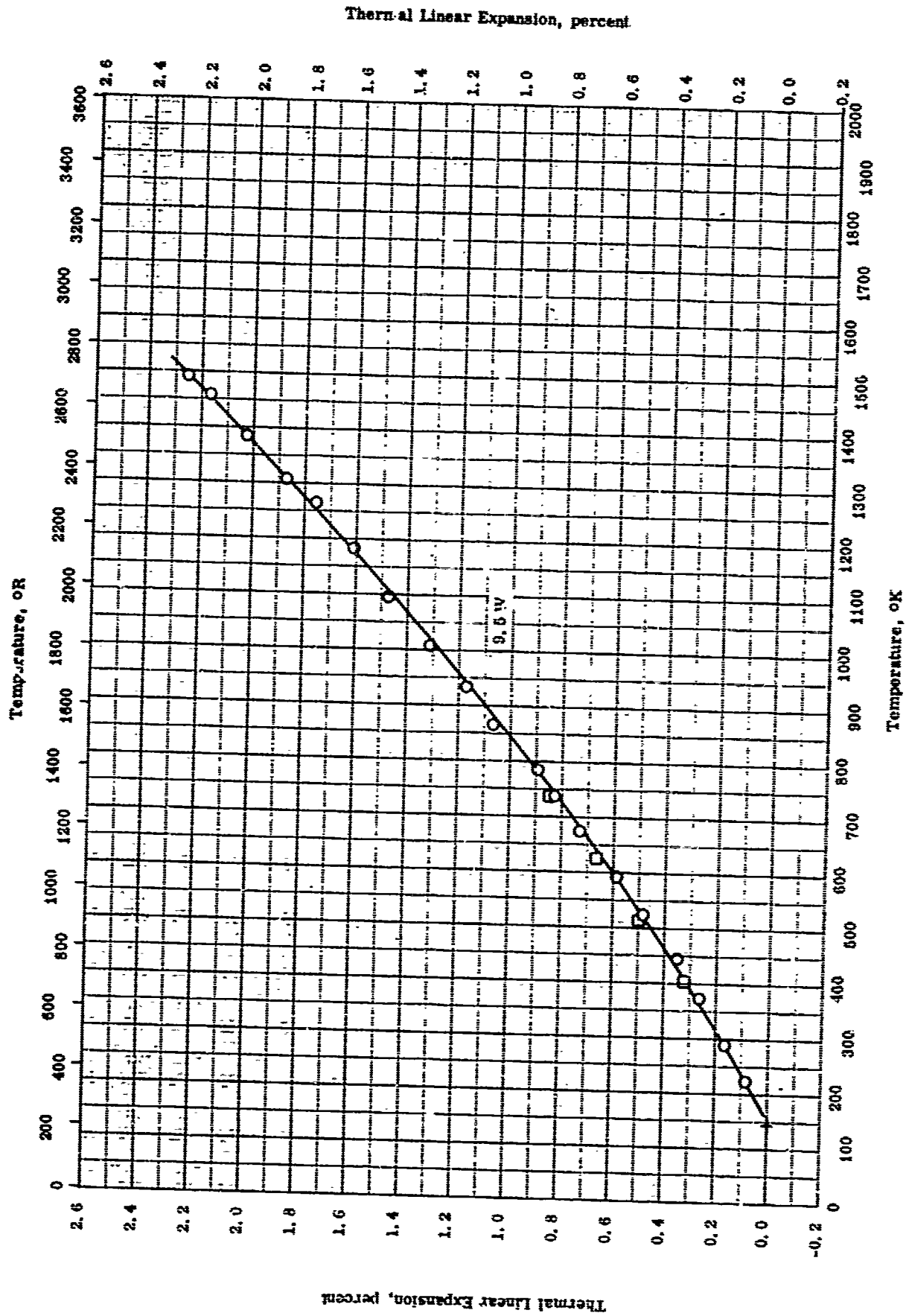
THERMAL DIFFUSIVITY -- TANTALUM + TUNGSTEN

TPRC

THERMAL DIFFUSIVITY --- TANTALUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|------|--------------------|-------------------|---|-----------------------|
| O | 63-1 | 1122-2852 | | 9.40 W, 0.10 Nb, 0.02 Ti, 0.02 Si, 0.01 Mo, 0.01 Ni, 0.005 Fe, 0.0040 C, 0.0090 O ₂ , and 0.0030 N ₂ ; density 16.58 g cm ⁻³ | Surface ground discs. |

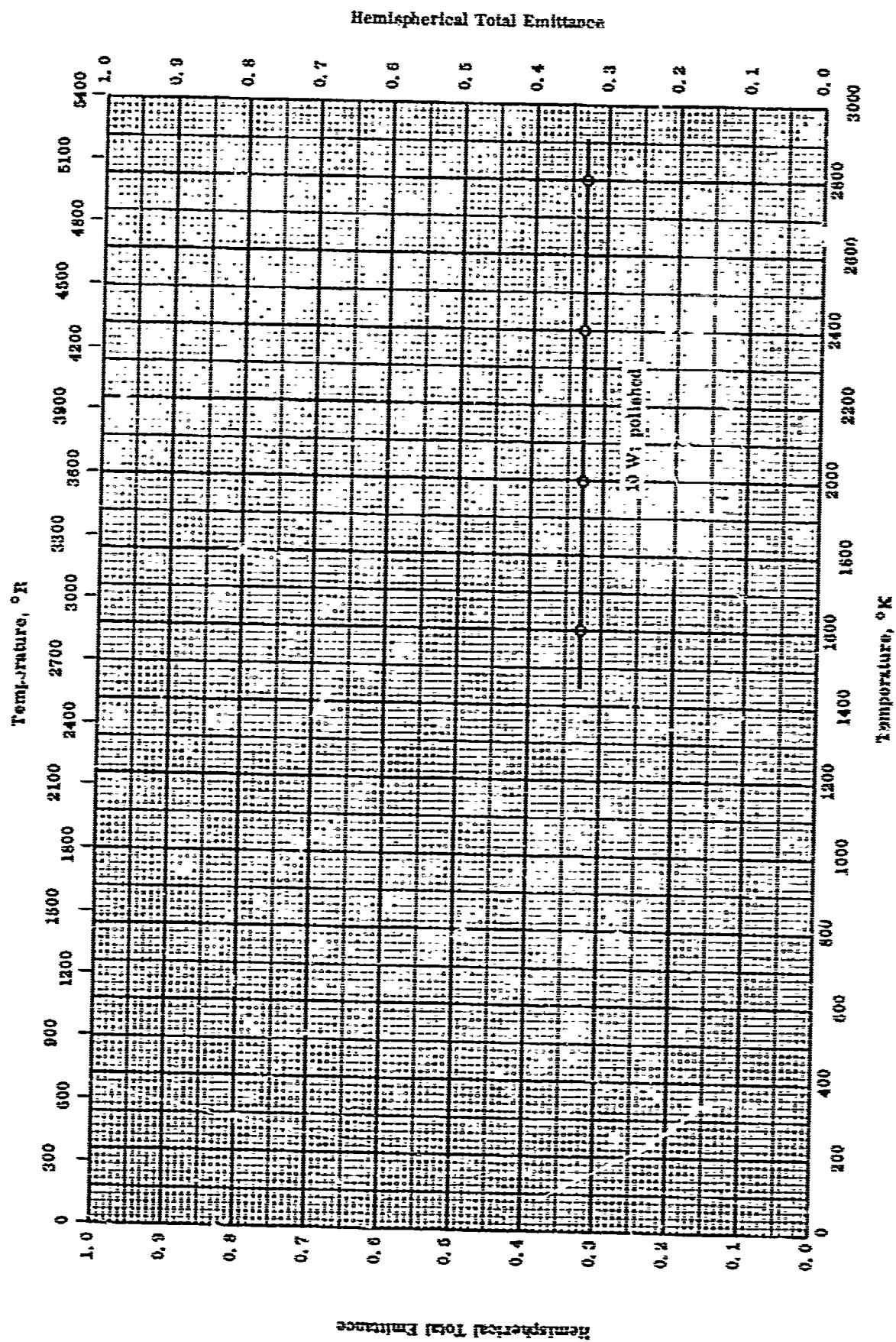


THERMAL LINEAR EXPANSION --- TANTALUM + TUNGSTEN

THERMAL LINEAR EXPANSION -- TANTALUM + TUNGSTEN

REFERENCE INFORMATION

| Sym Bsl | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ○ | 63-1 | 300-2081 | 2 | Fansteel Metallurgical Corp. ; 90.34 Ta, 9.50 W, 0.087 Nb, 0.015 Mo, 0.02 Ti, 0.005 Fe, 0.02 Si, 0.0010 C, 0.0050 O, and 0.0030 N; dimension 1/2 in. diameter by 6 in. long. | Measured in argon with heating rate of approx. 5 F min ⁻¹ . |
| □ | 63-27 | 100-1476 | 5 | 90 Ta, 10 W. | Measured in argon. |



HEMISPHERICAL TOTAL EMITTANCE -- TANTALUM TUNGSTEN

HEMISPHERICAL TOTAL EMITTANCE -- TANTALUM + TUNGSTEN

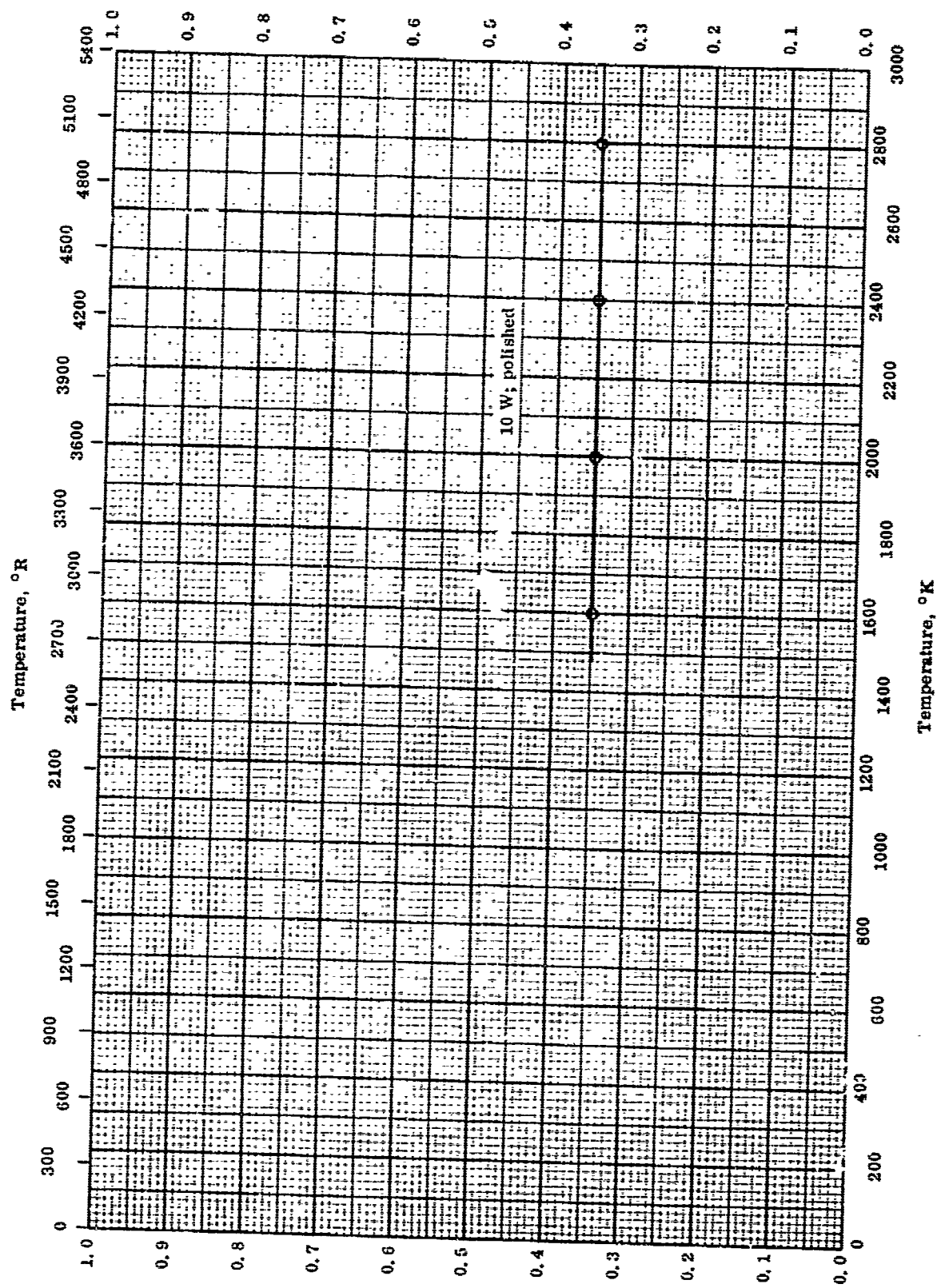
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|-----------------------|--|
| O | 62-20 | 1600-2800 | | 90 Ta and 10 W. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000) ; measured in argon. |

TPRC

Hemispherical Spectral Emittance

479



HEMISPHERICAL SPECTRAL EMITTANCE -- TANTALUM + TUNGSTEN

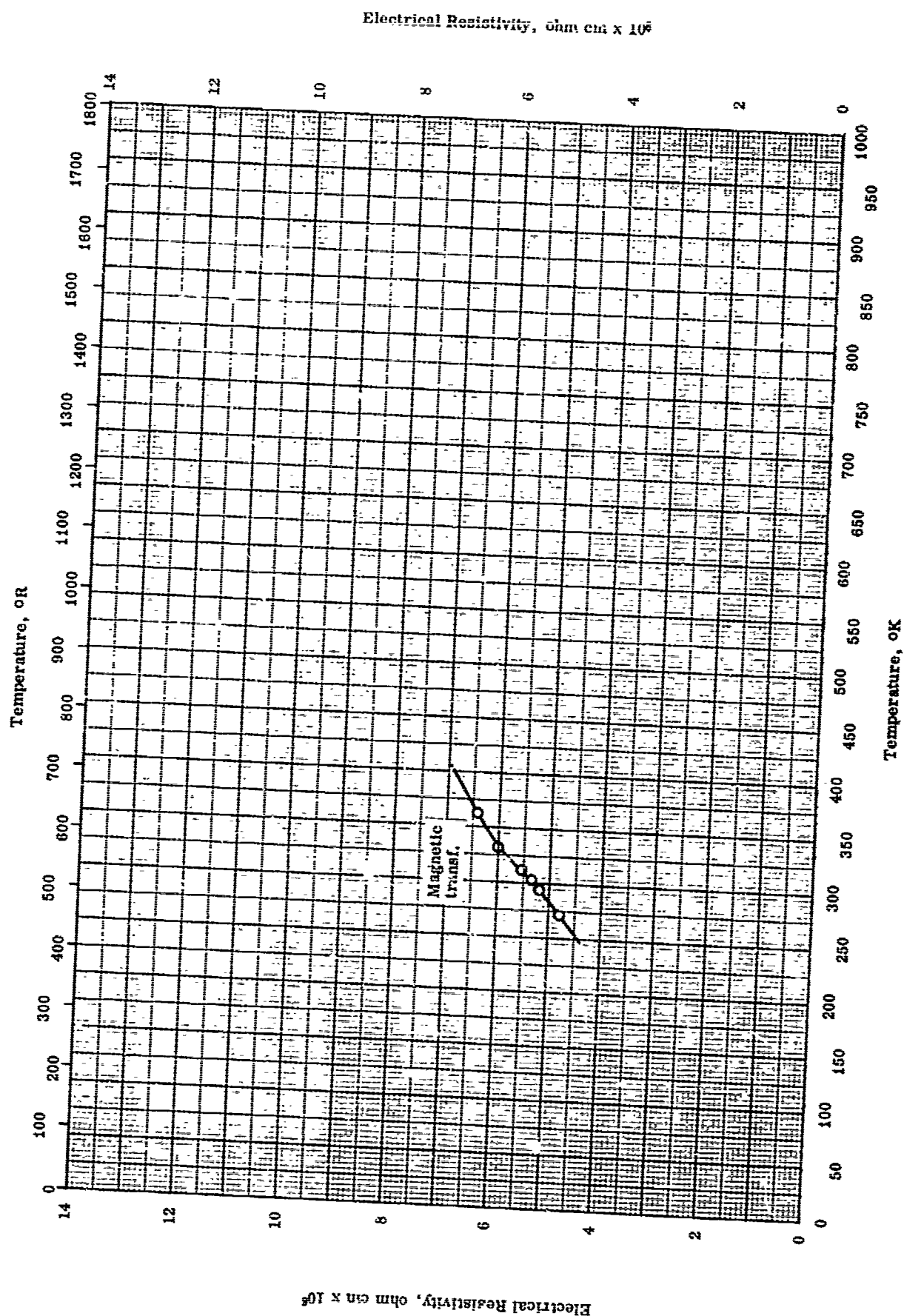
TPRC

HEMISPHERICAL SPECTRAL EMITTANCE -- TANTALUM + TUNGSTEN

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. °K Range | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|---------------------|-------------------|------------------|-----------------------|---|
| O | 62-20 | 0.65 | 1600-2500 | | 90 Ta and 10 W. | Polished with abrasive papers (No. 1, 0, 00, 000 and 0000); measured in argon. |

TPRC



ELECTRICAL RESISTIVITY -- TELLURIUM + CHROMIUM

ELECTRICAL RESISTIVITY -- TELLURIUM + CHROMIUM

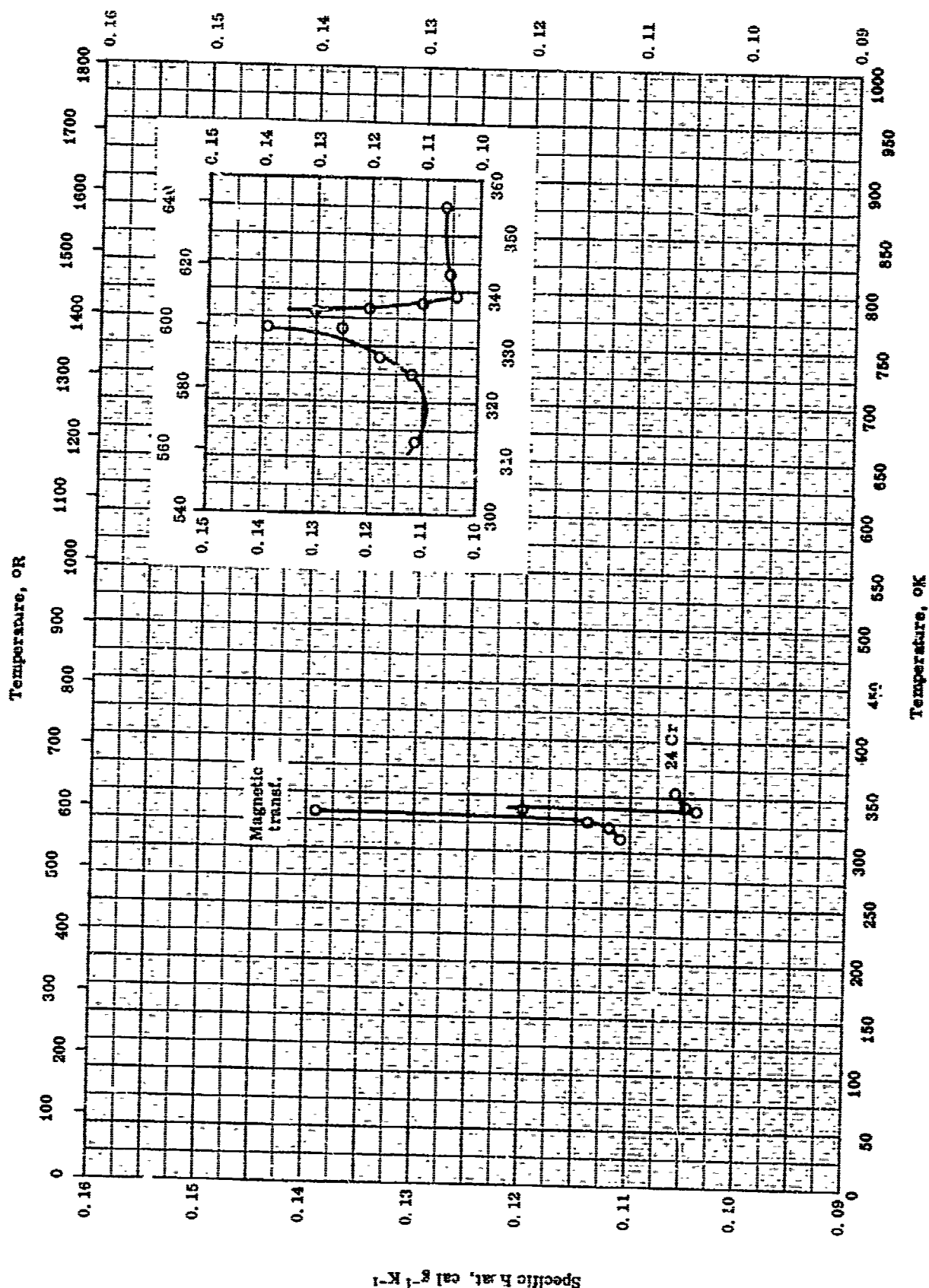
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---------------------------------|---|
| O | 49-8 | 273-363 | | Nominal: 69.79 To and 30.21 Gr. | Melted in silica tube at 1250 C in A atmos. |

TPRC

Specific Heat, Btu lb⁻¹ R⁻¹

483



SPECIFIC HEAT -- TELLURIUM + CHROMIUM

TPRC

SPECIFIC HEAT -- TELLURIUM + CADMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|------|--------------------|-------------------|-----------------------|---|
| O | 49-3 | 313-355 | | 75.7 Te and 24.3 Cr. | Prepared by fusion of Cr and Te powders at 1200 C under vacuum. |

TPRC

PROPERTIES OF THORIUM - PLUTONIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------|--------------------|---------------------|
| ○ 20 Pu | 12.15 | 758 |
| □ 46 Pu | 12.79 | 798 |

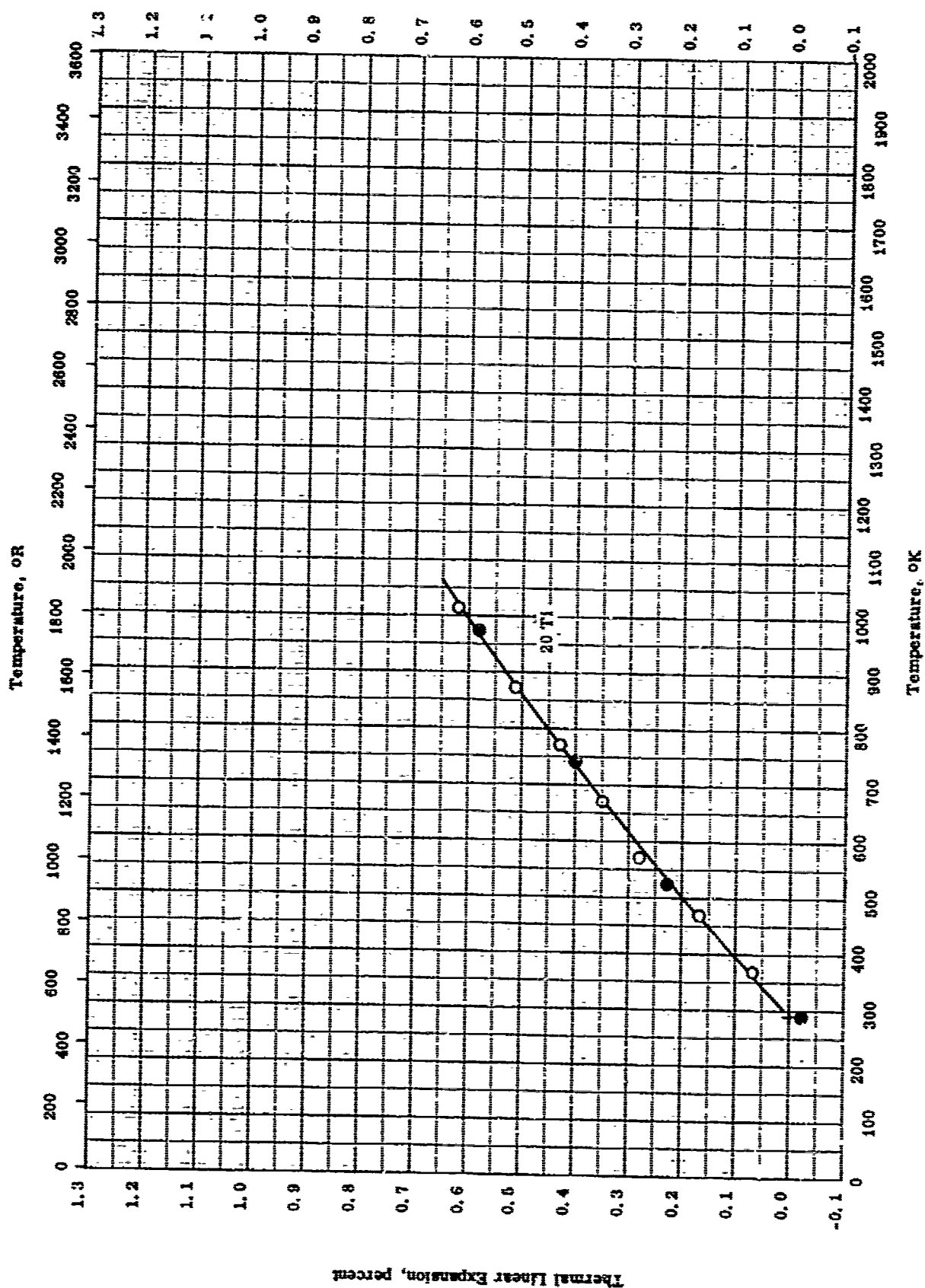
PROPERTIES OF THORIUM + PLUTONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 57-37 | 300 | | 20 Pa. | Density from weight in air, in water, and in ethylene bromide. |
| □ | 57-37 | 300 | | 46 Pa. | Same as above. |

Thermal Linear Expansion, percent

487



Thermal Linear Expansion --- THORIUM + TITANIUM

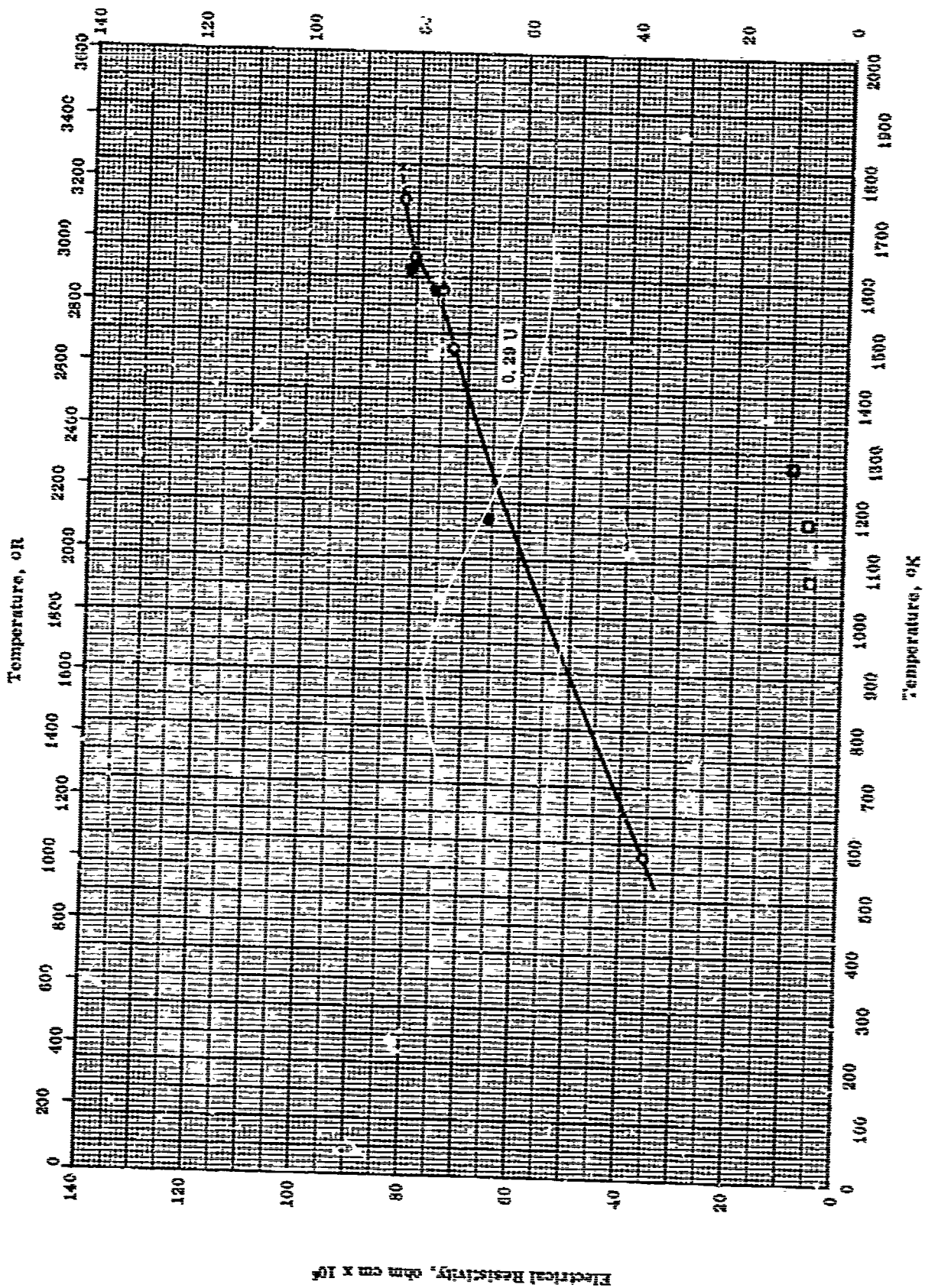
THERMAL LINEAR EXPANSION -- THORIUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------|
| ○ | 52-23 | 293-1013 | | 80 Th and 20 Ti. | Heating. |
| ● | 52-23 | 293-1013 | | Same as above. | Cooling. |

Electrical Resistivity, $\Omega\text{cm cm} \times 10^6$

455



ELECTRICAL RESISTIVITY -- THORIUM + URANIUM

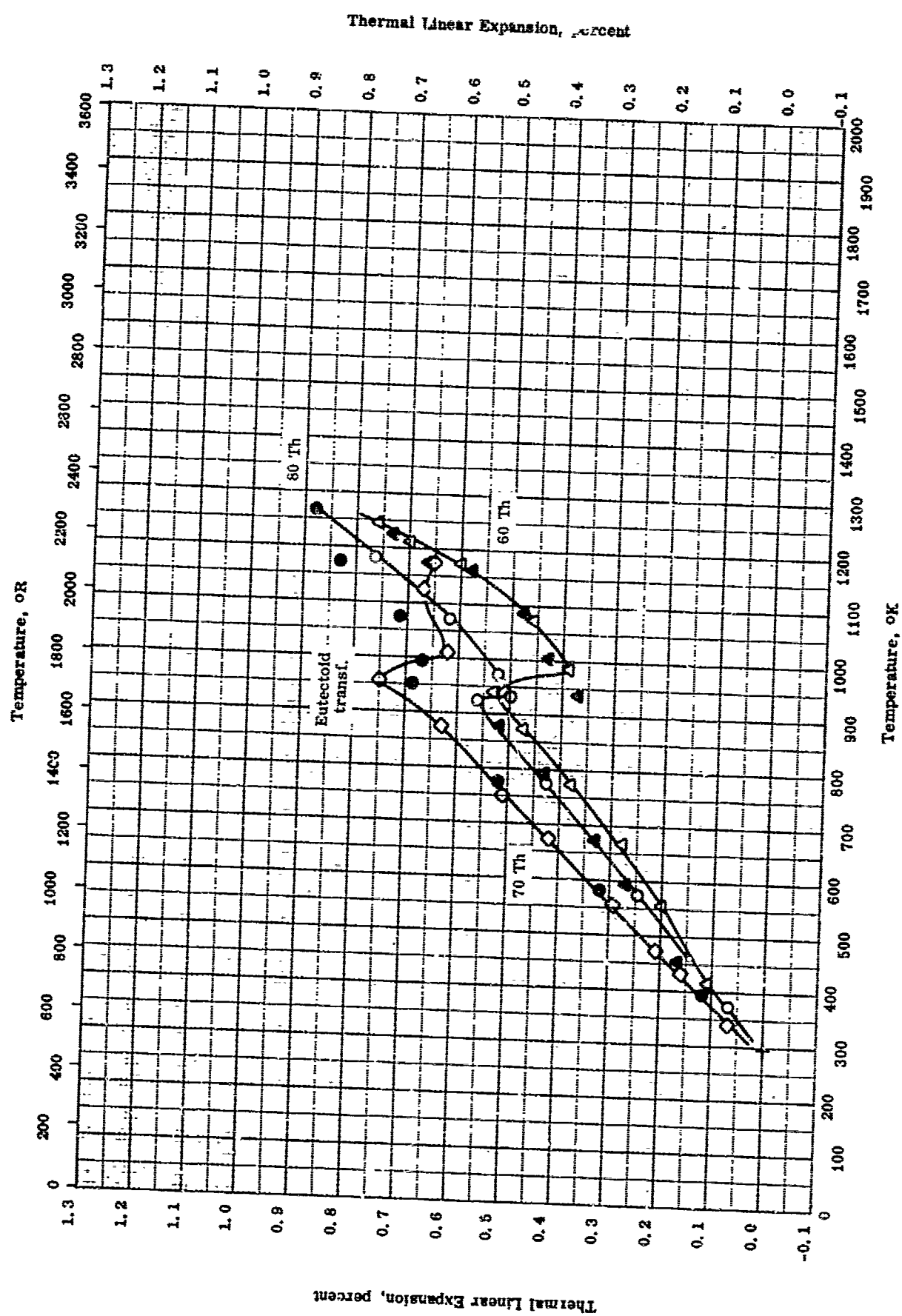
TPFC

ELECTRICAL RESISTIVITY -- THORIUM + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| □ | 57-30 | 1073-1273 | ± 2 | 2-10 U. | Are melted 5-7 times in He atmos. , cast, cold swaged, annealed, and water quenched. Measured heating. Above sample measured cooling. |
| ○ | 58-26 | 312-1743 | | 0.29 U, 0.29 U alloy, 0.031 O, 0.005 C, 0.002 H, N, each, and balance Th. | |
| ● | 58-20 | 313-1743 | | Same as above. | |

TPRC



THERMAL LINEAR EXPANSION -- THORIUM + ZIRCONIUM

TPRC

THERMAL LINEAR EXPANSION --- THORIUM + ZIRCONIUM

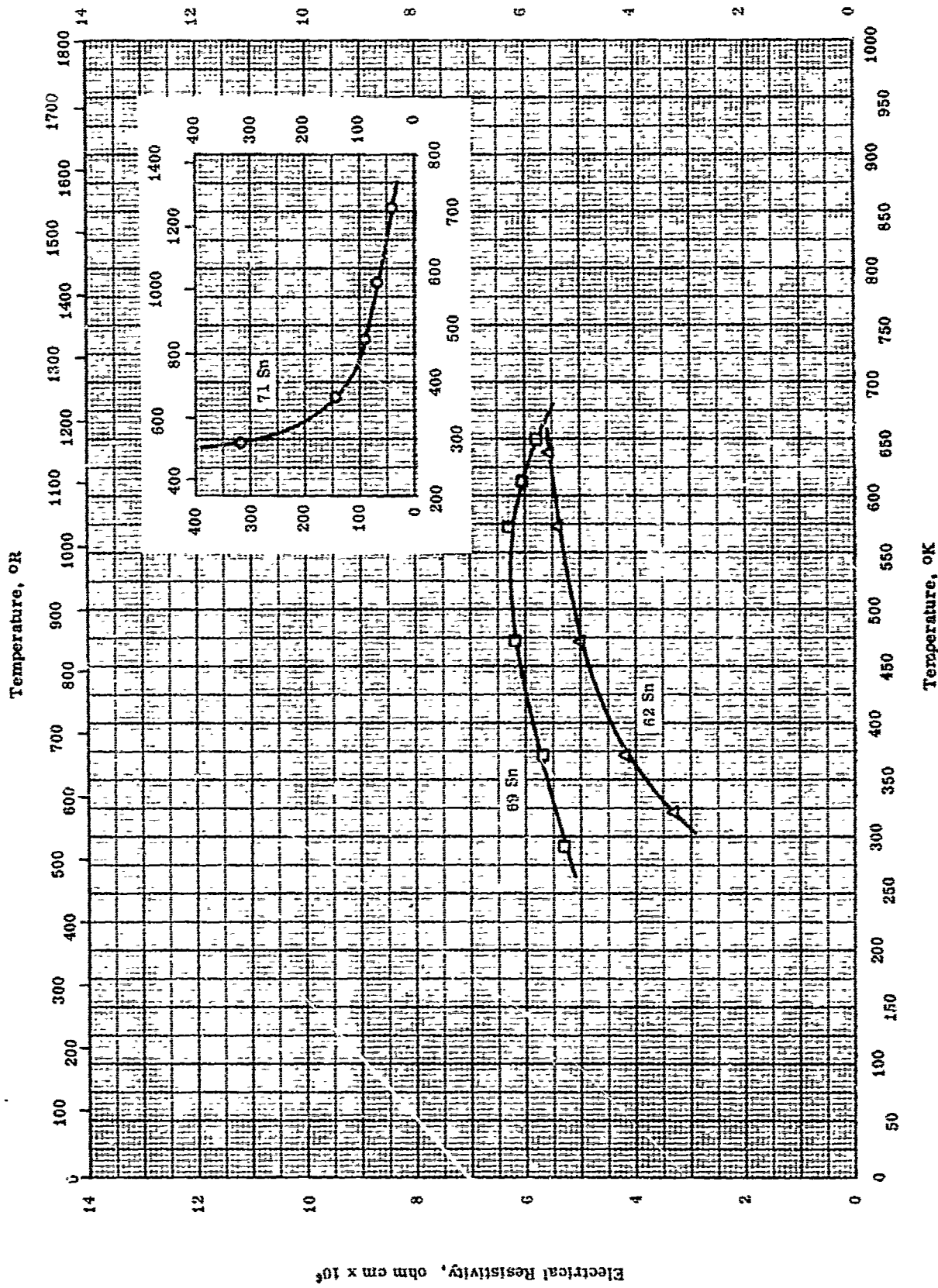
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------|
| ○ | 52-23 | 293-1263 | | 80 Th and 20 Zr. | Heating. |
| ● | 52-23 | 293-1263 | | Same as above. | Cooling. |
| ◇ | 52-23 | 293-1173 | | 70 Th and 30 Zr. | |
| △ | 52-23 | 293-1248 | | 50 Th and 40 Zr. | Heating. |
| ▲ | 52-23 | 293-1248 | | Same as above. | Cooling. |

TPRC

Electrical Resistivity, ohm cm x 10⁶

493

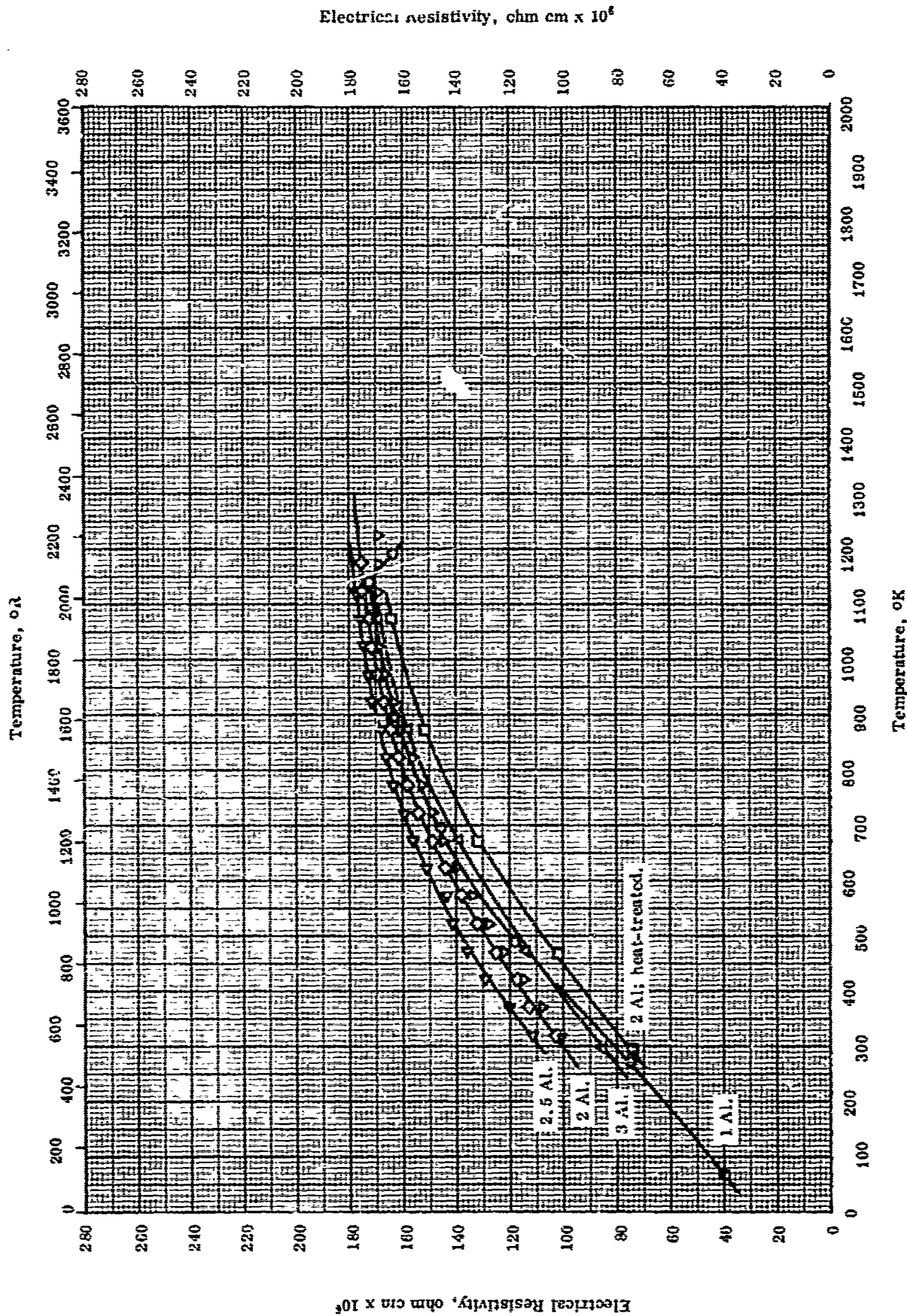


ELECTRICAL RESISTIVITY --- TIN + MAGNESIUM

ELECTRICAL RESISTIVITY -- TIN + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---------|
| ○ | 49-1 | 293-703 | | 71.1 Sn and 28.9 Mg. | |
| □ | 49-7 | 293-348 | | 68.5 Sn and 31.5 Mg. | |
| △ | 49-7 | 323-638 | | 62.4 Sn and 37.6 Mg. | |



ELECTRICAL RESISTIVITY -- TITANIUM + ALUMINUM
(1.0 \leq Al \leq 3.0)

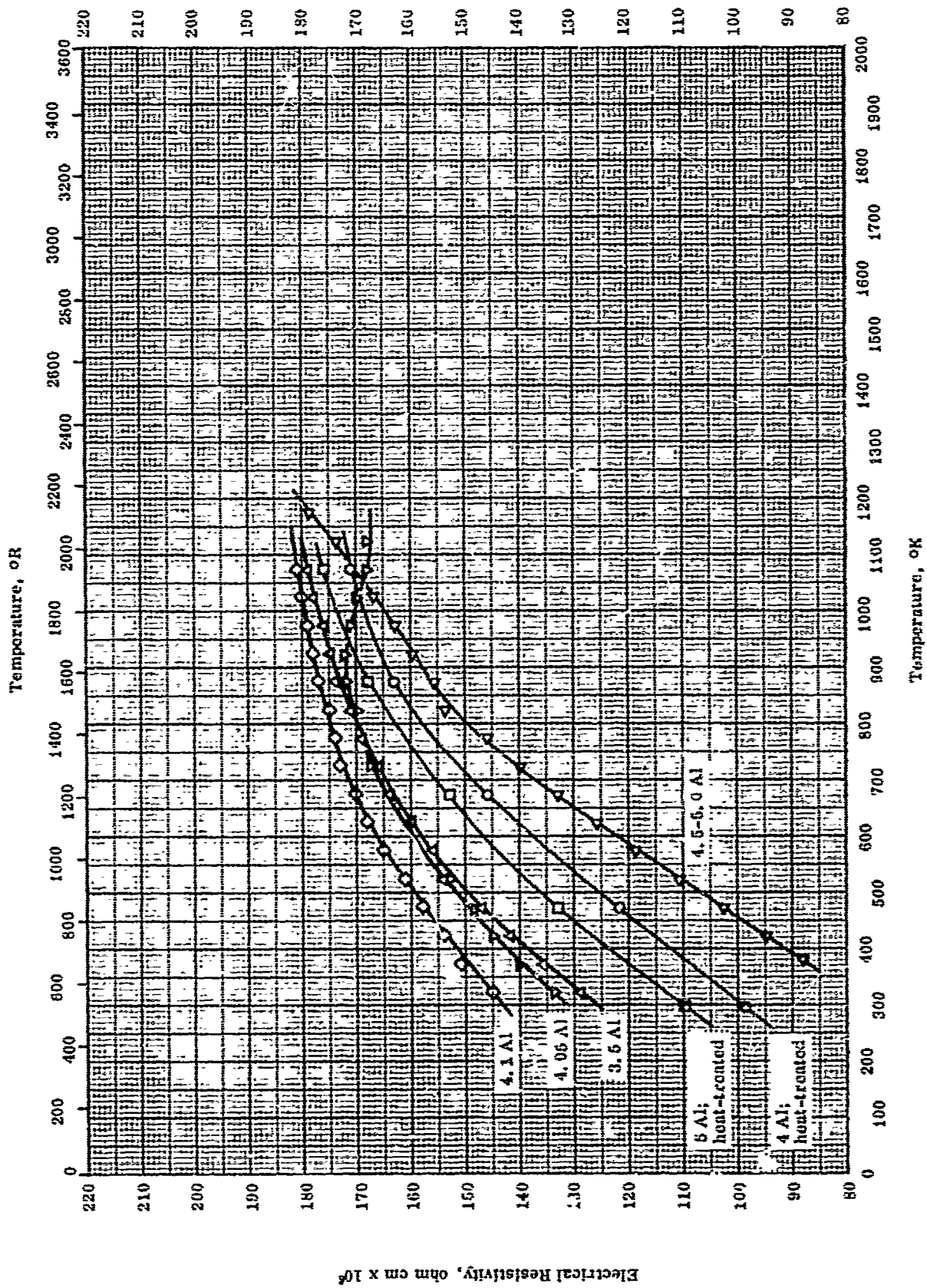
ELECTRICAL RESISTIVITY --- TITANIUM + ALUMINUM
(1.0 \pm Al \pm 3.0)

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|---|--|
| ○ | 56-30 aisc 58-31 | 70-1193 | | 1.0 Al; made from pure iodide - Ti or 99.99 pure Mg - reduced Ti and 99.99 Al. | Melted in arc furnace with W electrode, in 99.995 pure A atm.; remelted twice more; difference between heating and cooling $<$ 3%. |
| □ | 56-18 | 298-1073 | ± 1 | Ti, α - phase; 2 Al. | High temperature work in vacuum of 10^{-6} mm Hg. Same as above. |
| △ | 56-18 | 298-1073 | | Ti, α - phase; 3 Al. | |
| ▽ | 61-11 | 323-1223 | | 1.5 Al. | |
| ◇ | 61-11 | 323-1173 | | 2.0 Al. | |
| ▽ | 61-11 | 323-1123 | | 2.5 Al. | |

Electrical Resistivity, ohm cm x 10⁶

497



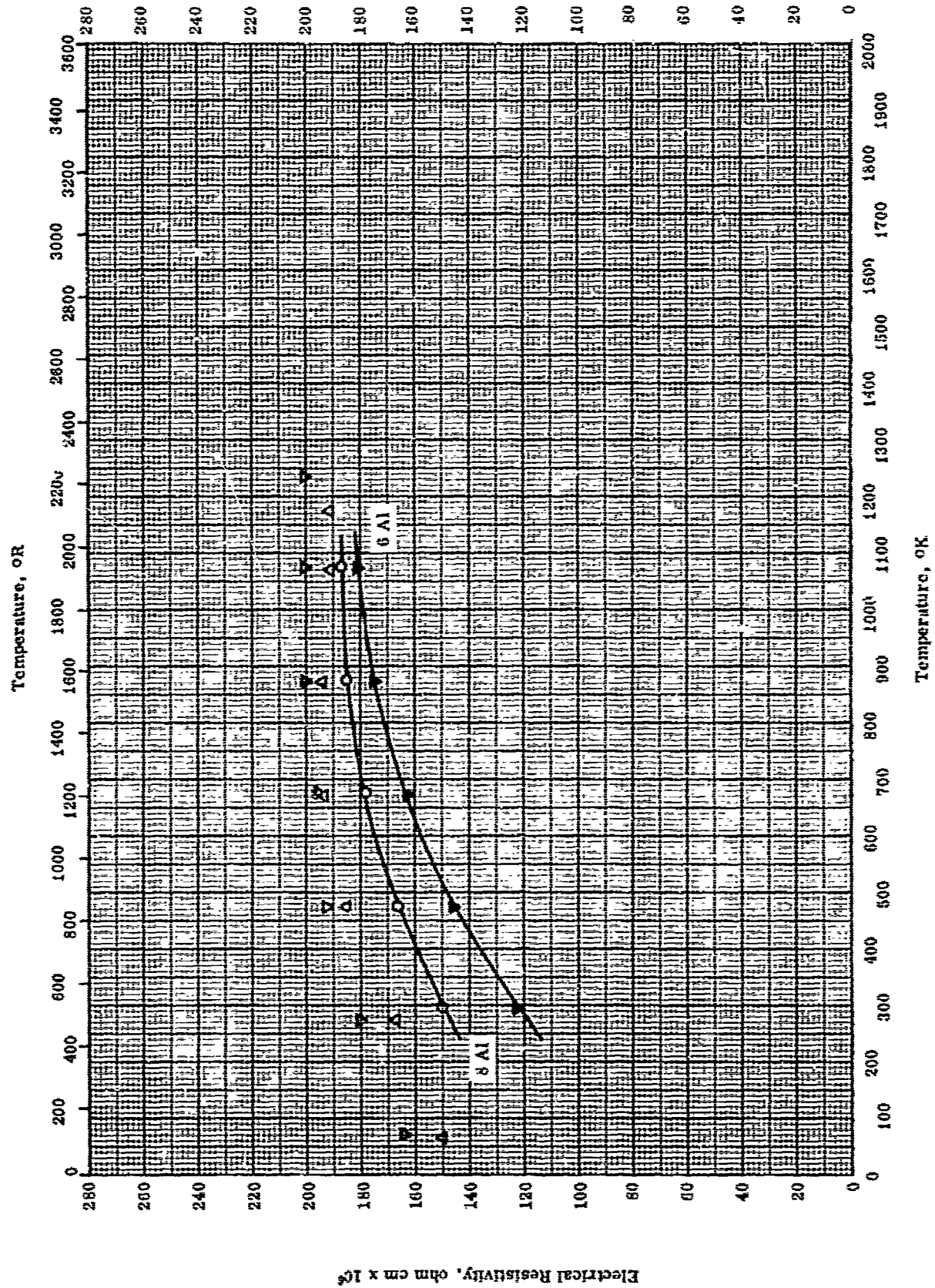
ELECTRICAL RESISTIVITY -- TITANIUM + ALUMINUM
(3.0 < Al ≤ 6.0)

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 50-18 | 298-1073 | ± 1 | Ti, α-phase; 4 Al. | High temp. work in vacuum of 10 ⁻⁴ mm Hg. Sample as above. |
| □ | 50-18 | 298-1073 | ± 1 | Ti, α-phase; 5 Al. | |
| △ | 01-11 | 323-1073 | | 3.5 Al. | |
| ▽ | 01-11 | 323-1123 | | 4.05 Al. | |
| ◇ | 01-11 | 323-1073 | | 4.1 Al. | |
| ◁ | 01-11 | 323-1173 | | 4.5-5.0 Al. | |

Electrical Resistivity, ohm cm x 10⁶

499



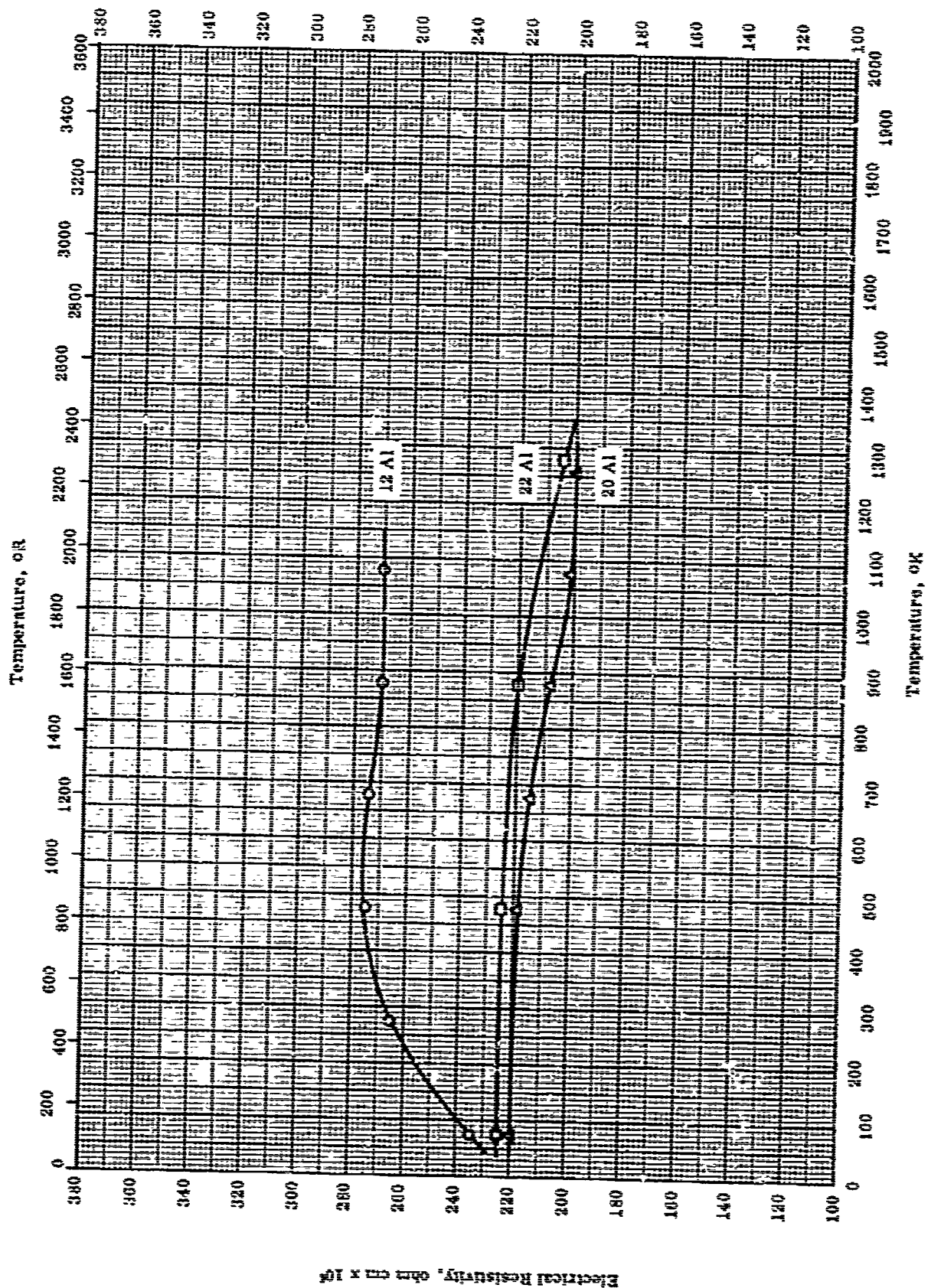
ELECTRICAL RESISTIVITY -- TITANIUM + ALUMINUM
(6 ≤ Al ≤ 8)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|--|---|
| ▼ | 50-18 | 298-1073 | ± 1 | Ti, α-phase; 6 Al. | High temperature work in vacuum of 10^{-4} mm Hg. |
| ○ | 55-18 | 298-1073 | ± 1 | Ti, α-phase; 8 Al. | Same as above. |
| △ | 50-30 also 55-31 | 68-1173 | | 7.0 Al; made from pure iodide-Ti or 99.96 mg-reduced Ti and 99.99 pure Al. | Melted in arc furnace with W electrode, in 99.995 pure A atm; remelted twice more; difference between heating and cooling < 3%. |
| ▽ | 55-30 also 55-31 | 73-1233 | | 8.0 Al; same as above. | Same as above. |

Electrical Resistivity, ohm cm $\times 10^6$

361



ELECTRICAL RESISTIVITY -- TITANIUM + ALUMINUM
(10% Al \pm 2%)

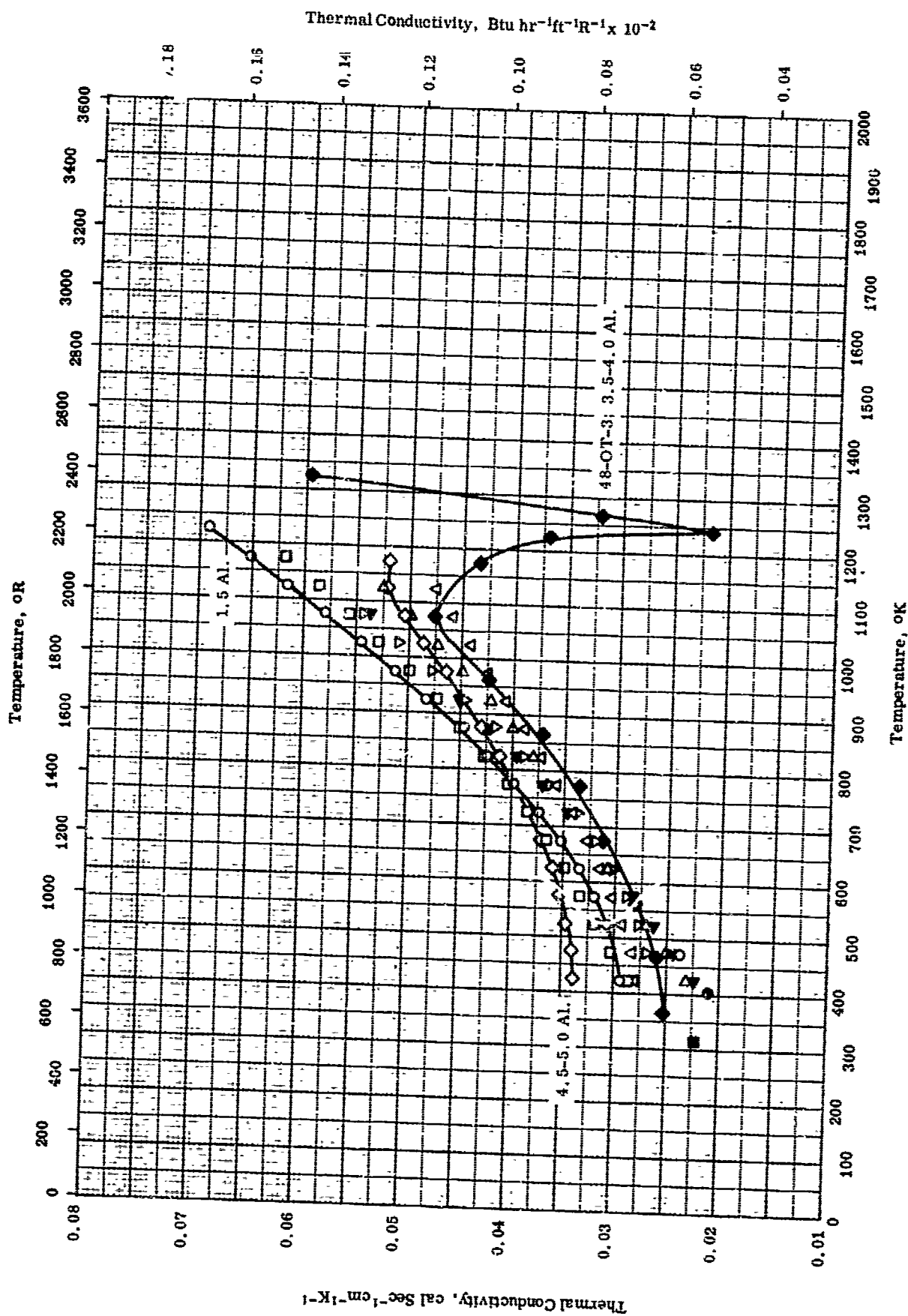
TPRC

ELECTRICAL RESISTIVITY -- TITANIUM + ALUMINUM
(10 < Al ≤ 22)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|---|---|
| ○ | 56-30 also 56-31 | 83-1273 | | 12 Al; prepared from iodide titanium or 99.96 pure Mg-reduced titanium and 99.99 pure Al. | Melted in ar. furnace with W electrode in 99.995 pure A atm. and remelted twice more; difference between heating and cooling runs less than 3%. |
| △ | 56-30 also 56-31 | 83-1113 | | 20 Al; same as above. | Same as above. |
| □ | 56-30 also 56-31 | 83-1233 | | 22 Al; same as above. | Same as above. |

TPRC



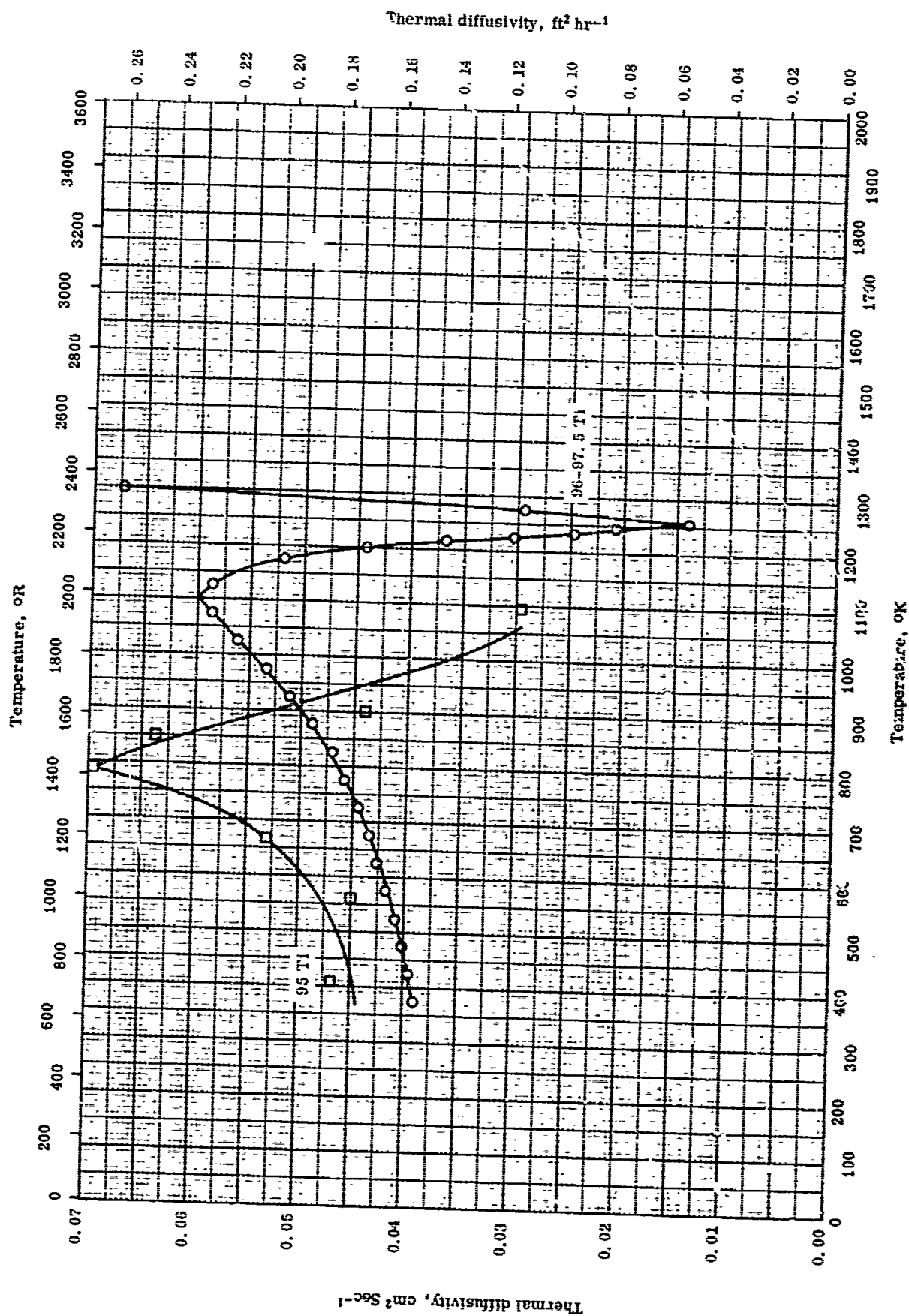
THERMAL CONDUCTIVITY -- TITANIUM + ALUMINUM

THERMAL CONDUCTIVITY -- TITANIUM + ALUMINUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| ● | 56-11 | 403 | | 7 Al. | |
| ■ | 56-12 | 317 | | 8 Al. | |
| ○ | 61-11 | 423-1223 | | 1.5 Al. | |
| □ | 61-11 | 423-1173 | | 2.0 Al. | |
| △ | 61-11 | 423-1123 | | 2.5 Al. | |
| ▽ | 61-11 | 473-1073 | | 3.5 Al. | |
| ▼ | 61-11 | 423-1073 | | 4.1 Al. | |
| △ | 61-11 | 423-1123 | | 4.05 Al. | |
| ◇ | 61-11 | 423-1173 | | 4.5 - 5.0 Al. | |
| ◆ | 61-6 | 366-1328 | | 3.5 - 4 Al, 0.1 > N ₂ , and 0.1 > O ₂ ; 48-OT-3. | |

TPRC



THERMAL DIFFUSIVITY -- TITANIUM + ALUMINUM

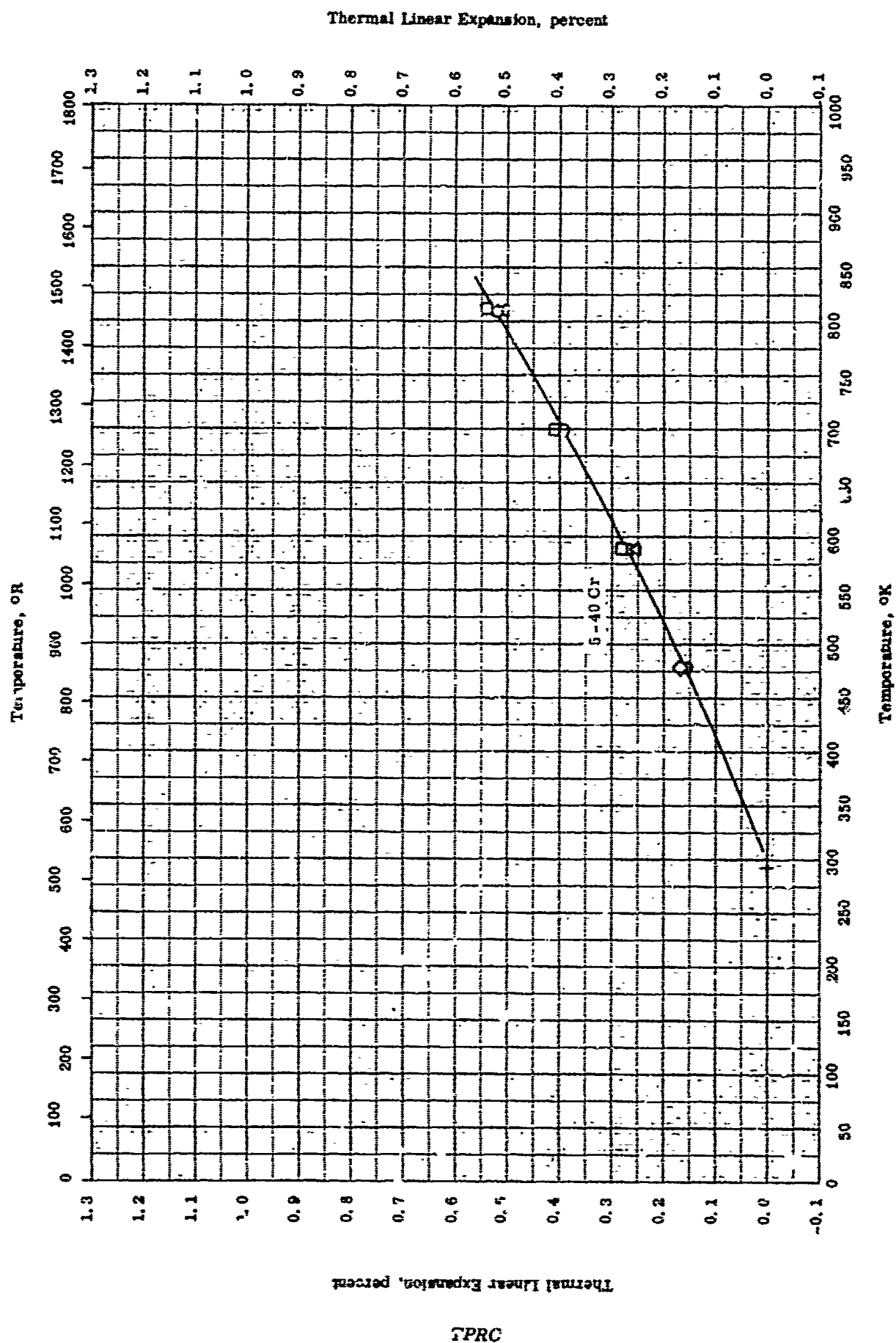
TPRC

THERMAL DIFFUSIVITY -- TITANIUM + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specification | Remarks |
|------------|------|--------------------|-------------------|---|---|
| O | 01-1 | 373-1298 | | 48-O1-3; 96-97.5 Ti, 3.5-4.0 Al, 0.1 O ₂ , 0.1 N ₂ , and trace H ₂ ; cylindrical sample with 100 mm dia and 400 mm long. | Vacuum annealed for 5 hrs at 720 C and annealed again in apparatus before beginning measurements. |
| O | 02-2 | 403-1023 | | R-T-5; 95 Ti and 5 Al; cylindrical sample with 3 mm dia and 300 mm long. | |

TPRC



THERMAL LINEAR EXPANSION -- TITANIUM + CHROMIUM

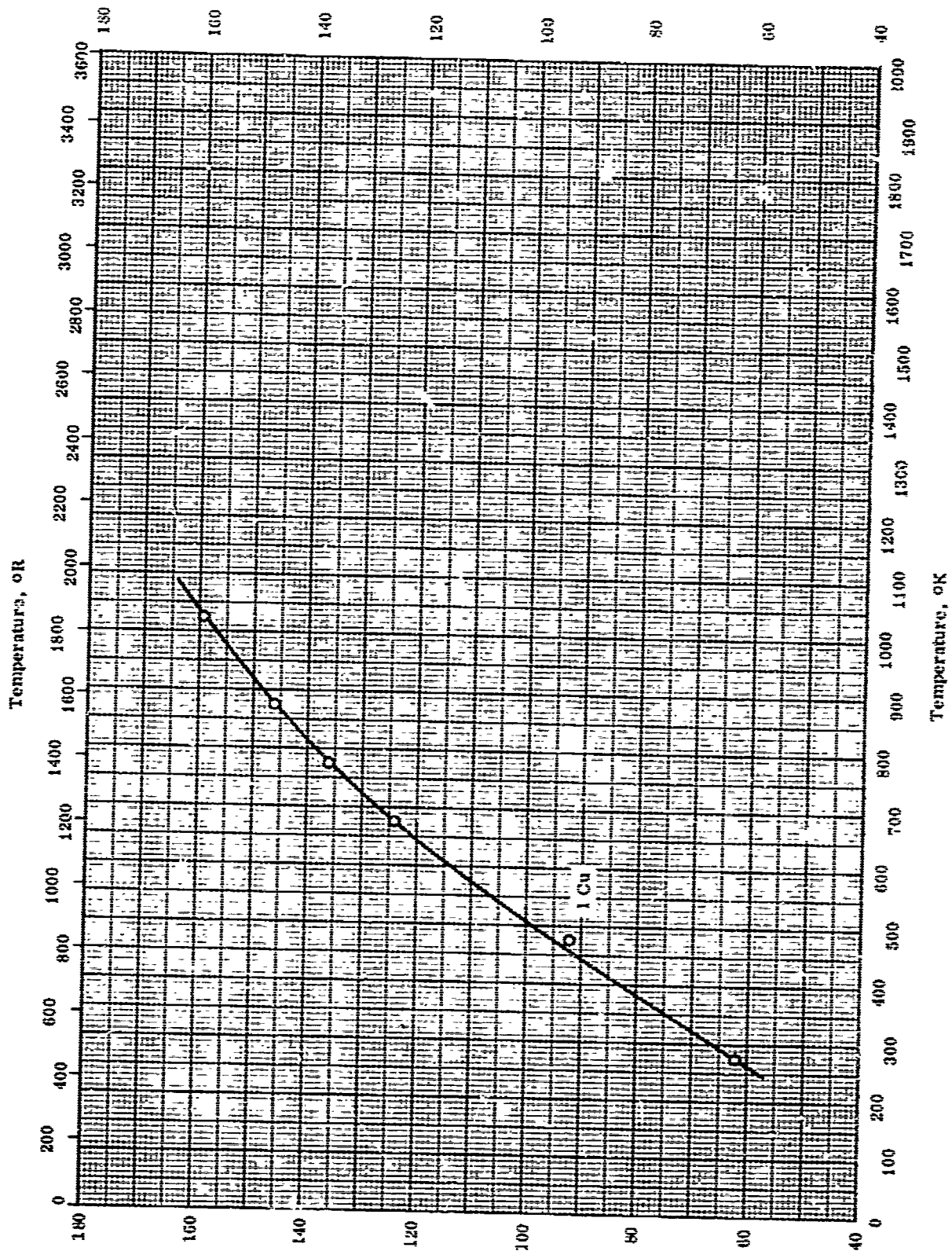
THERMAL LINEAR EXPANSION -- TITANIUM + CHROMIUM

REFERENCE INFORMATION

| Syn Dot | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 54-33 | 297-811 | | 5.0 Cr. | |
| □ | 54-33 | 297-811 | | 10.0 Cr. | |
| ◇ | 54-33 | 297-478 | | 15.0 Cr. | |
| △ | 54-33 | 297-811 | | 40.0 Cr. | |

Electrical Resistivity, ohm cm x 10⁶

509



ELECTRICAL RESISTIVITY - TITANIUM + COPPER

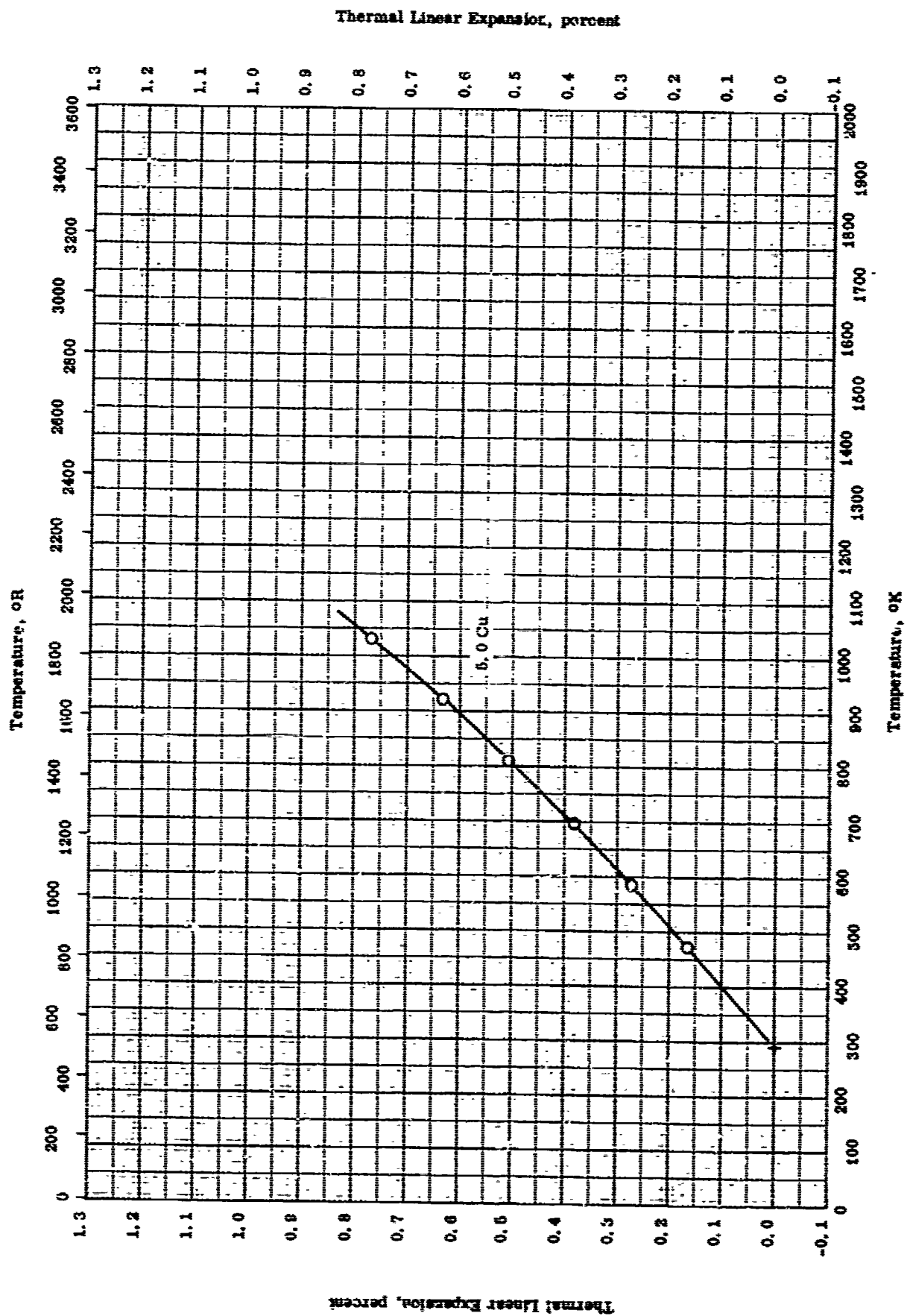
TPRC

ELECTRICAL RESISTIVITY -- TITANIUM + COPPER

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| O | 50-18 | 273-1023 | ± 1 | Iodide Ti (α - phase) ; 1 Cu (99.99 pure) . | High temp. work in vacuum of 10^{-6} mm Hg. |

TPRC

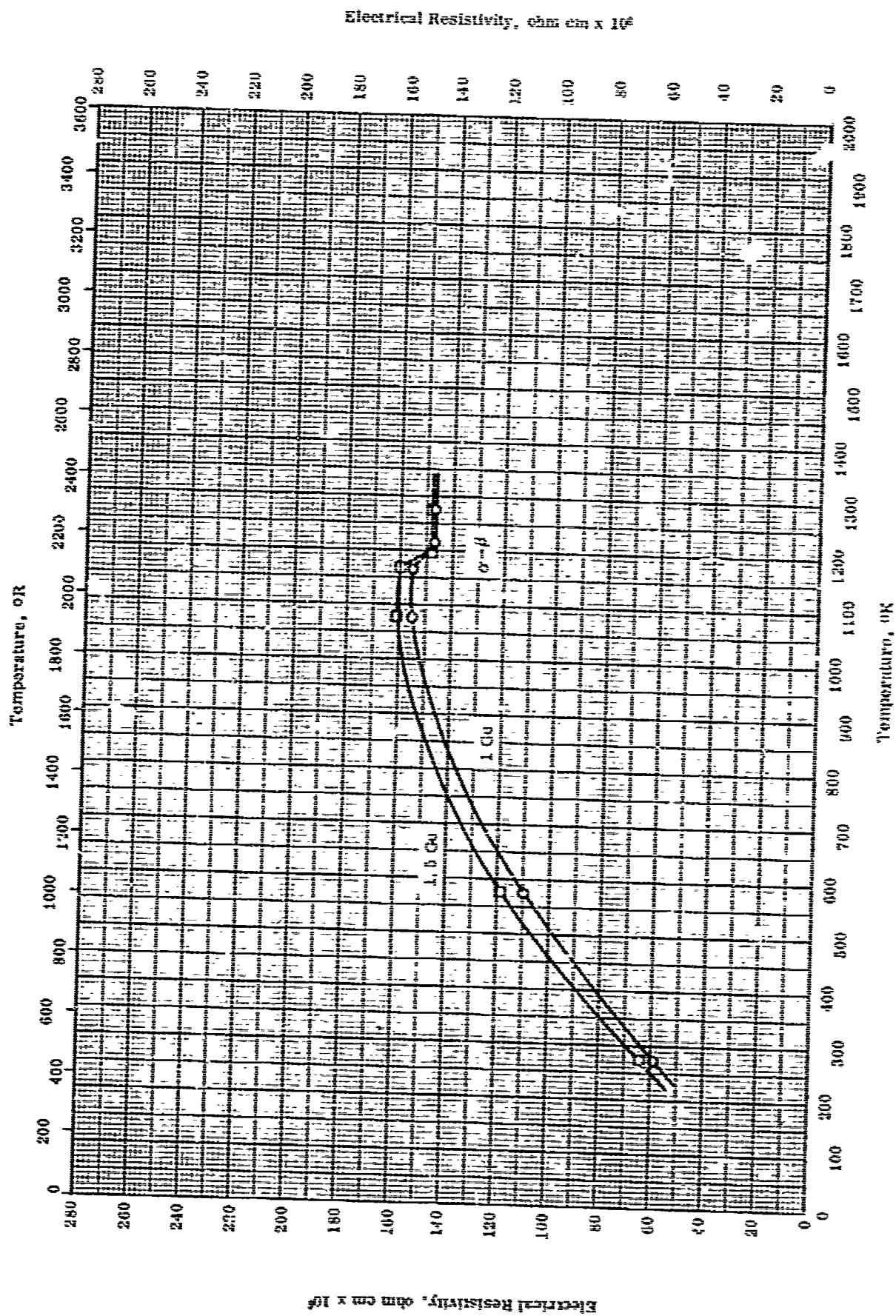


THERMAL LINEAR EXPANSION -- TITANIUM + COPPER

THERMAL LINEAR EXPANSION -- TITANIUM + COPPER

REFERENCE INFORMATION

| Sym Enl | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|--------|-------------------|------------------|-----------------------|---------|
| ○ | 64-113 | 297-1033 | | 5.0 Cu. | |



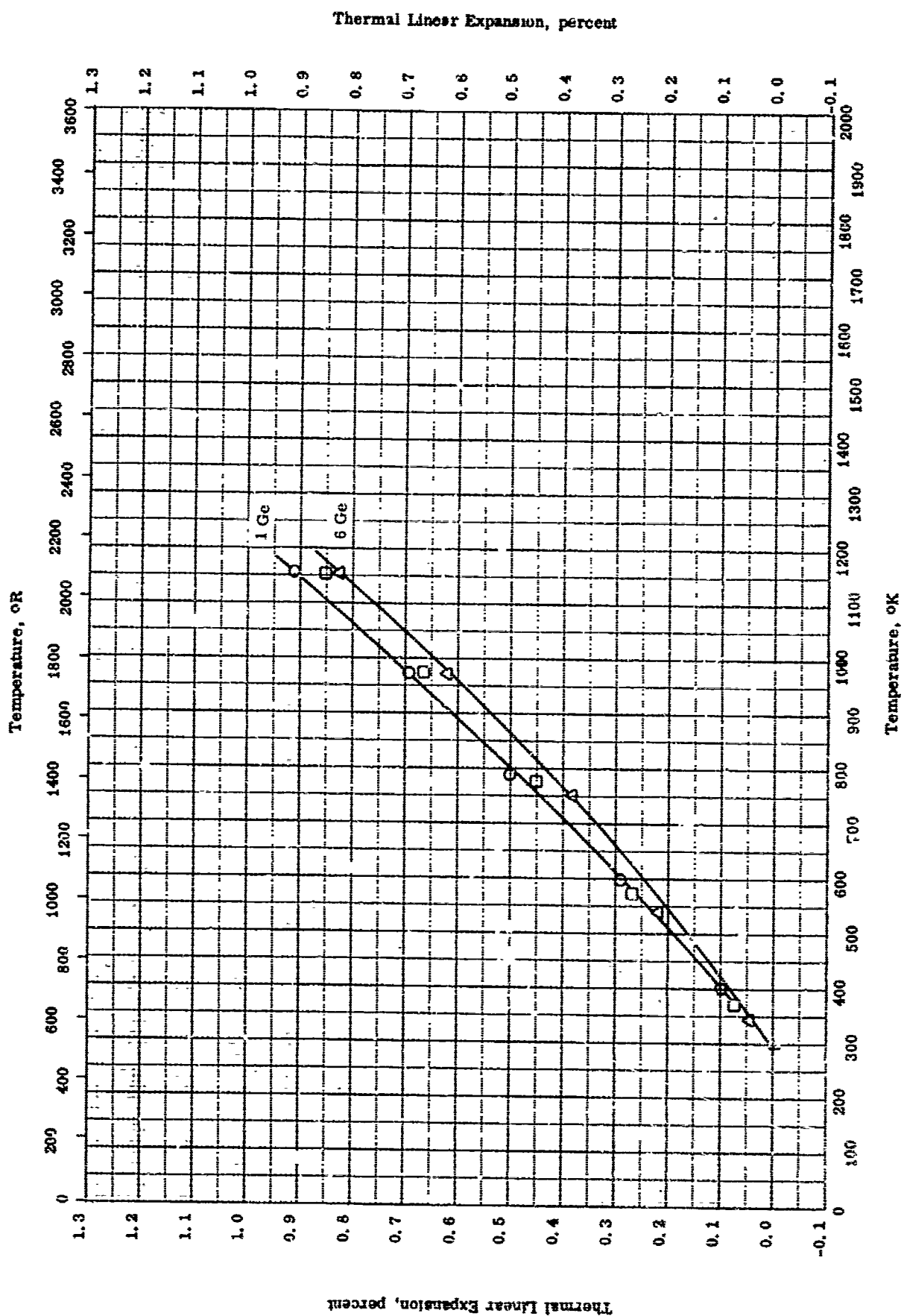
ELECTRICAL RESISTIVITY - TITANIUM - GERMANIUM

ELECTRICAL RESISTIVITY -- TITANIUM + GERMANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|-----------------------|---------------------------------------|
| ○ | 55-24 | 273-1273 | | 99 Ti and 1 Ge. | Heating rate 50 C min ⁻¹ . |
| □ | 55-24 | 273-1273 | | 98.5 Ti and 1.5 Ge. | Same as above. |

TPRC



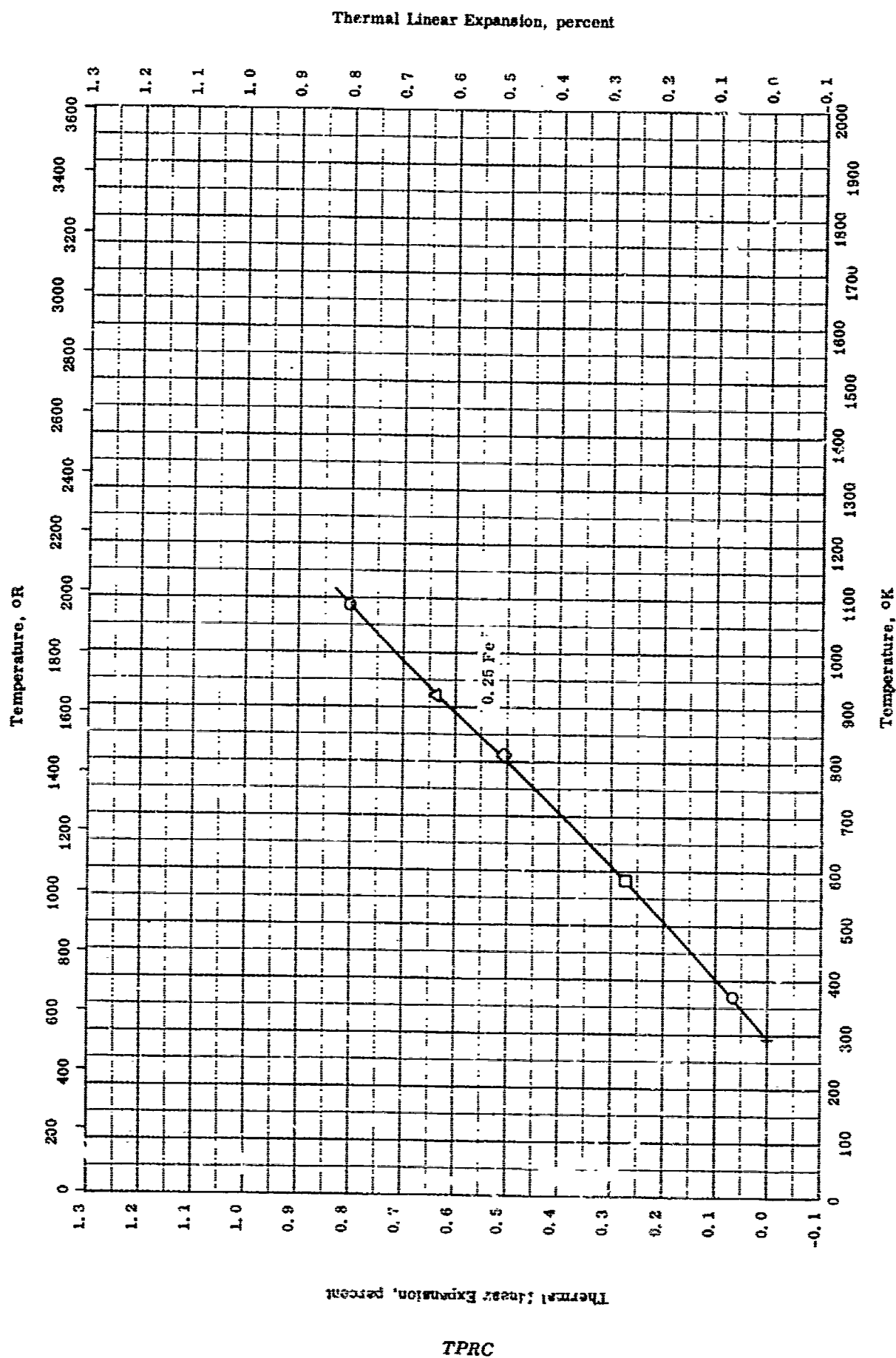
THERMAL LINEAR EXPANSION -- TITANIUM + GERMANIUM

THERMAL LINEAR EXPANSION -- TITANIUM + GERMANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------------------------------------|
| ○ | 55-24 | 293-1156 | | 1 Gr. | Heating rate 50 C min ⁻¹ . |
| □ | 55-24 | 293-1156 | | 2 Gr. | Same as above. |
| △ | 55-24 | 293-1156 | | 6 Gr. | Same as above. |

TPRC

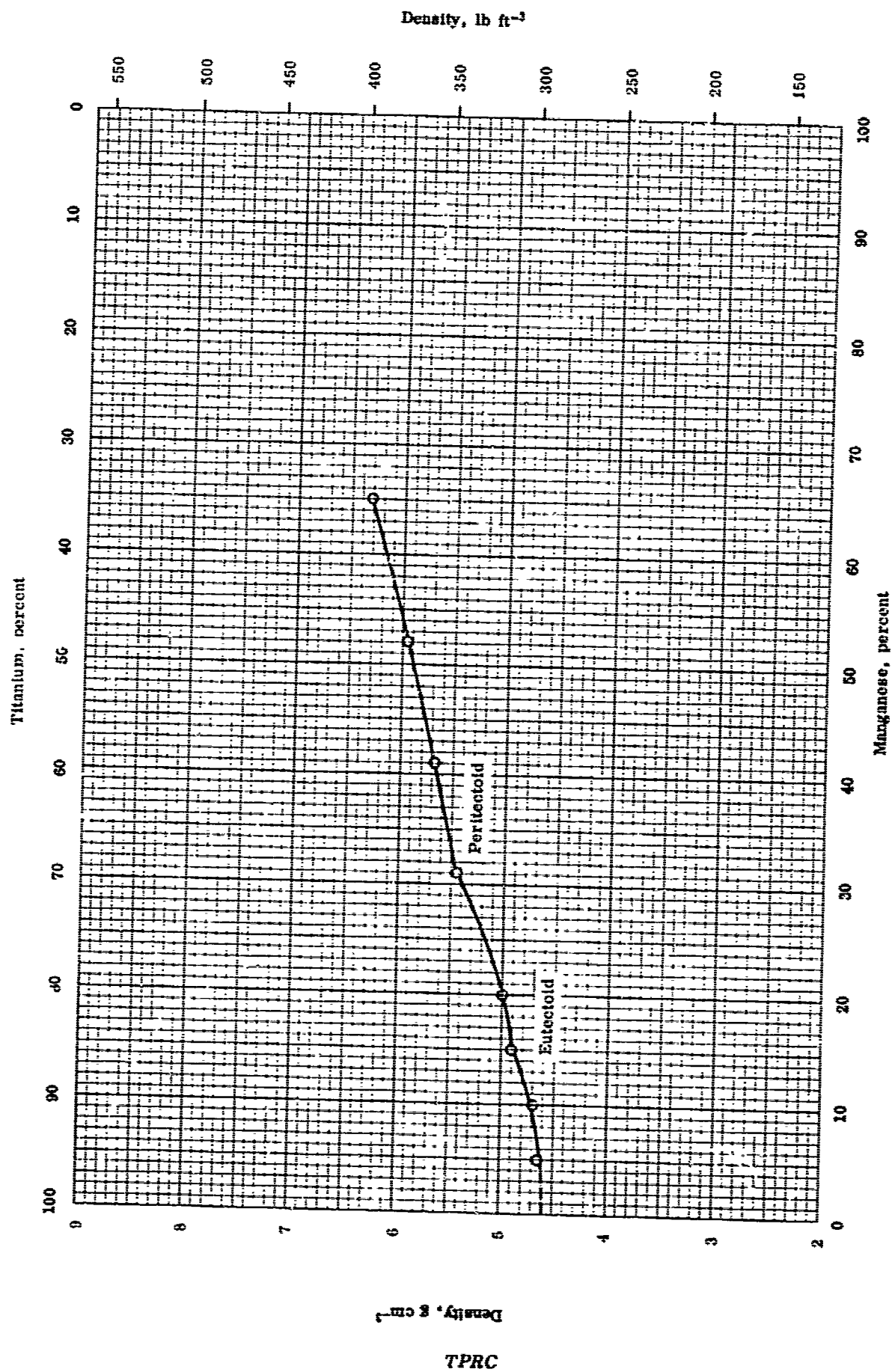


THERMAL LINEAR EXPANSION -- TITANIUM + IRON

THERMAL LINEAR EXPANSION -- TITANIUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|---|
| ○ | 65-6 | 27°-1089 | | RMI - 30; Reactive Metals, Inc.; 0.25 Fe, 0.08 C, 0.05 N, and 0.01 - 0.015 H; density 0.133 lb in. ⁻³ and M.P. ~ 3040 F; beta transus 1630 ± 25 F. | Annealing temperature: full 1300 F for 2 hrs and air cooled; stress relief at 1000 - 1100 F for 30 min. and air cooled; forging temperature: blocking 1600 - 1700 F, finishing 1500 - 1600 F. |
| □ | 65-6 | 273-1089 | | RMI - 40; Reactive Metals, Inc.; 0.25 Fe, 0.08 C, 0.05 N, and 0.010 - 0.015 H; density 0.163 lb in. ⁻³ and M.P. ~ 3020 F; beta transus 1675 ± 25 F. | Same as above. |
| ◇ | 65-6 | 273-1089 | | RMI - 55; Reactive Metals, Inc.; 0.25 Fe, 0.08 C, 0.05 N, and 0.010 - 0.015 H; density 0.163 lb in. ⁻³ and M.P. ~ 3020 F; beta transus 1690 ± 25 F. | Same as above. |
| △ | 65-6 | 273-1089 | | RMI - 70; Reactive Metals, Inc.; 0.25 Fe, 0.08 C, 0.05 N, and 0.010 - 0.015 H; density 0.164 lb in. ⁻³ and M.P. ~ 3020 F; beta transus 1740 ± 25 F. | Same as above except forging temperature: blocking 1650 - 1700 F, finishing 1500 - 1600 F. |



DENSITY -- TITANIUM + MANGANESE

DENSITY -- TITANIUM + MANGANESE

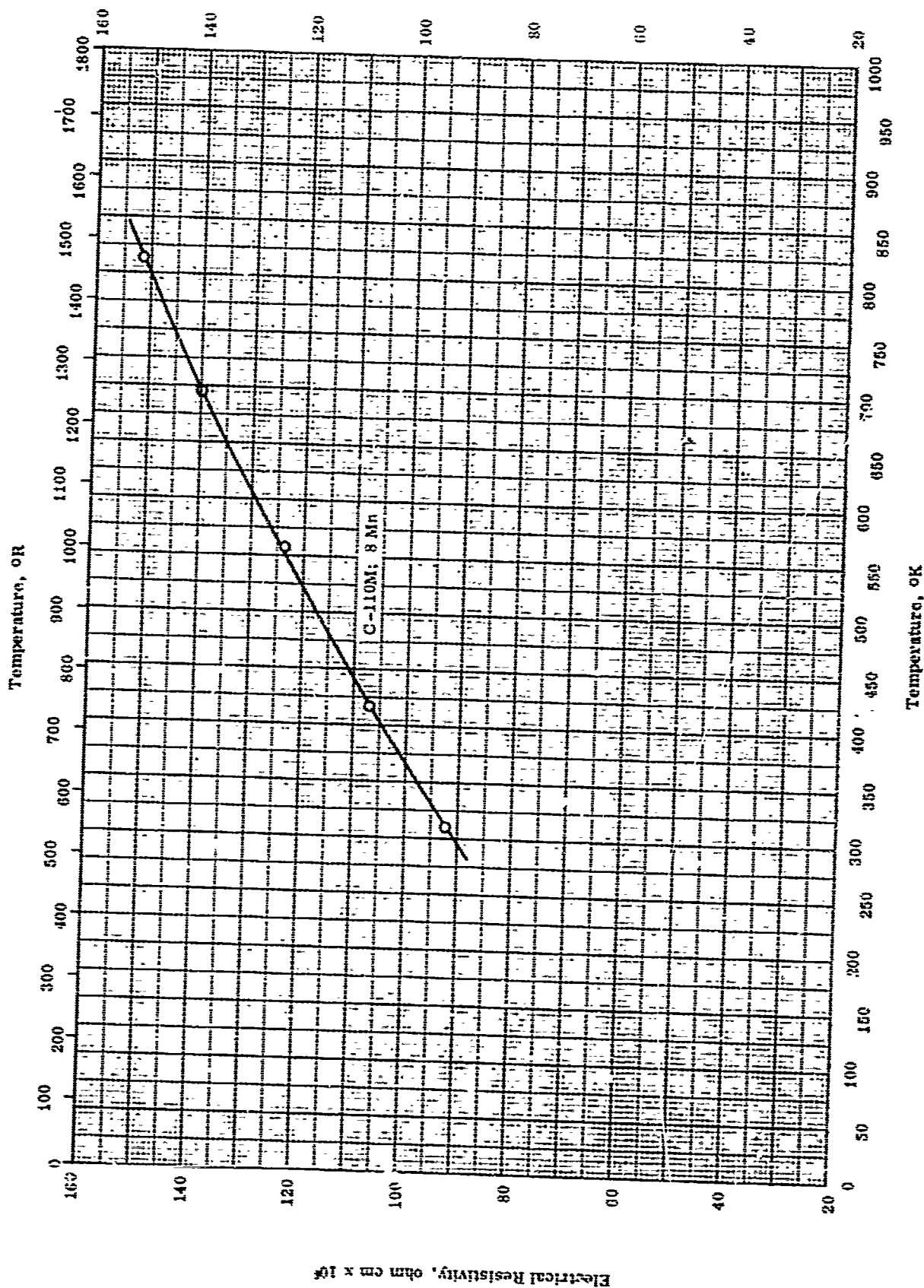
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °C | Rpt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-----------------------|--|
| ○ | 64-20 | 298 | | 0-05 Mn. | Density by weight in air and in water. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$

521



ELECTRICAL RESISTIVITY -- TITANIUM + MANGANESE

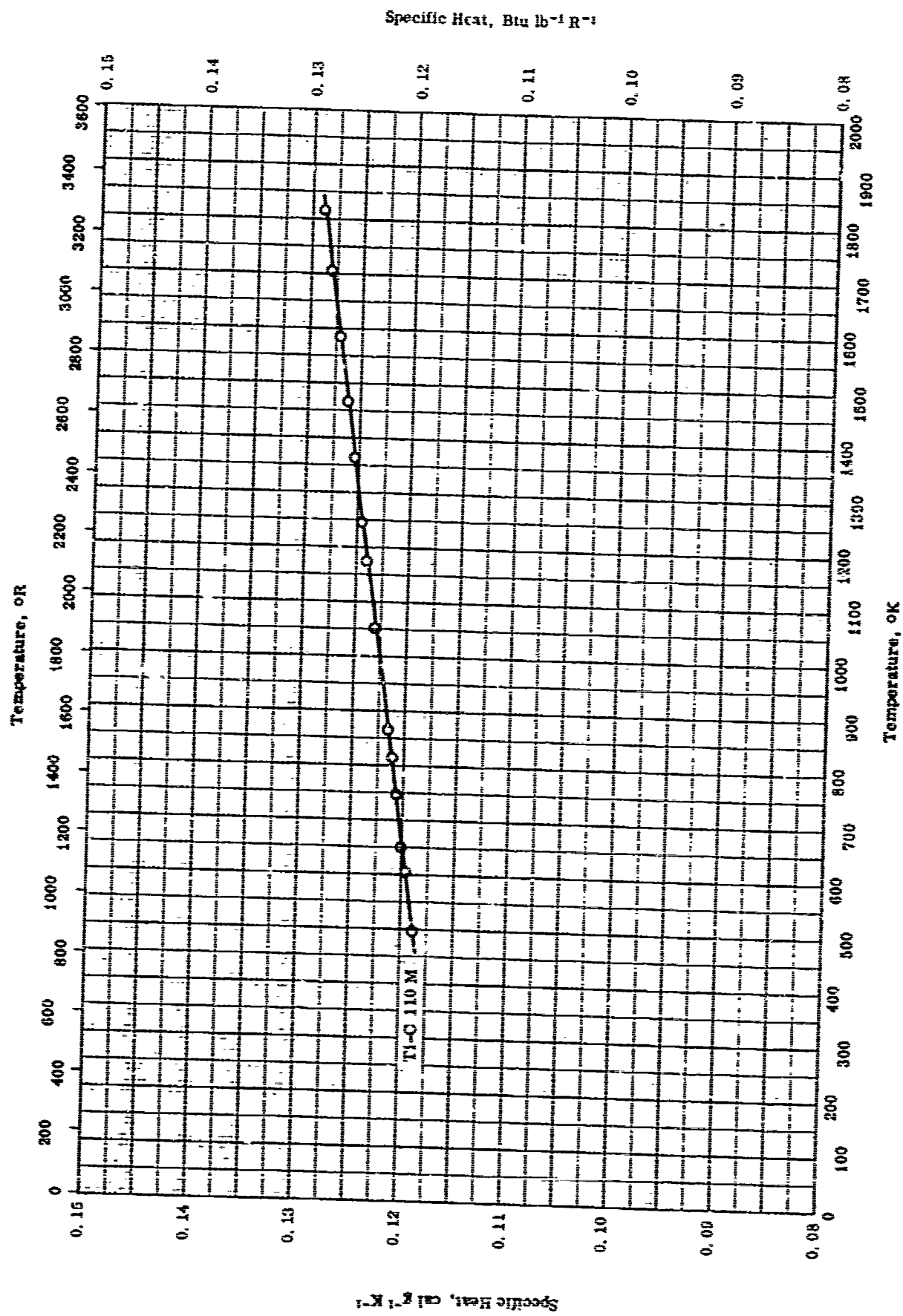
TPRC

ELECTRICAL RESISTIVITY -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---------|
| O | 56-14 | 311-811 | ± 1 | Ti alloy C-110M (formerly RC-130A); nominal composition; 8 Mn. | |

TPRC

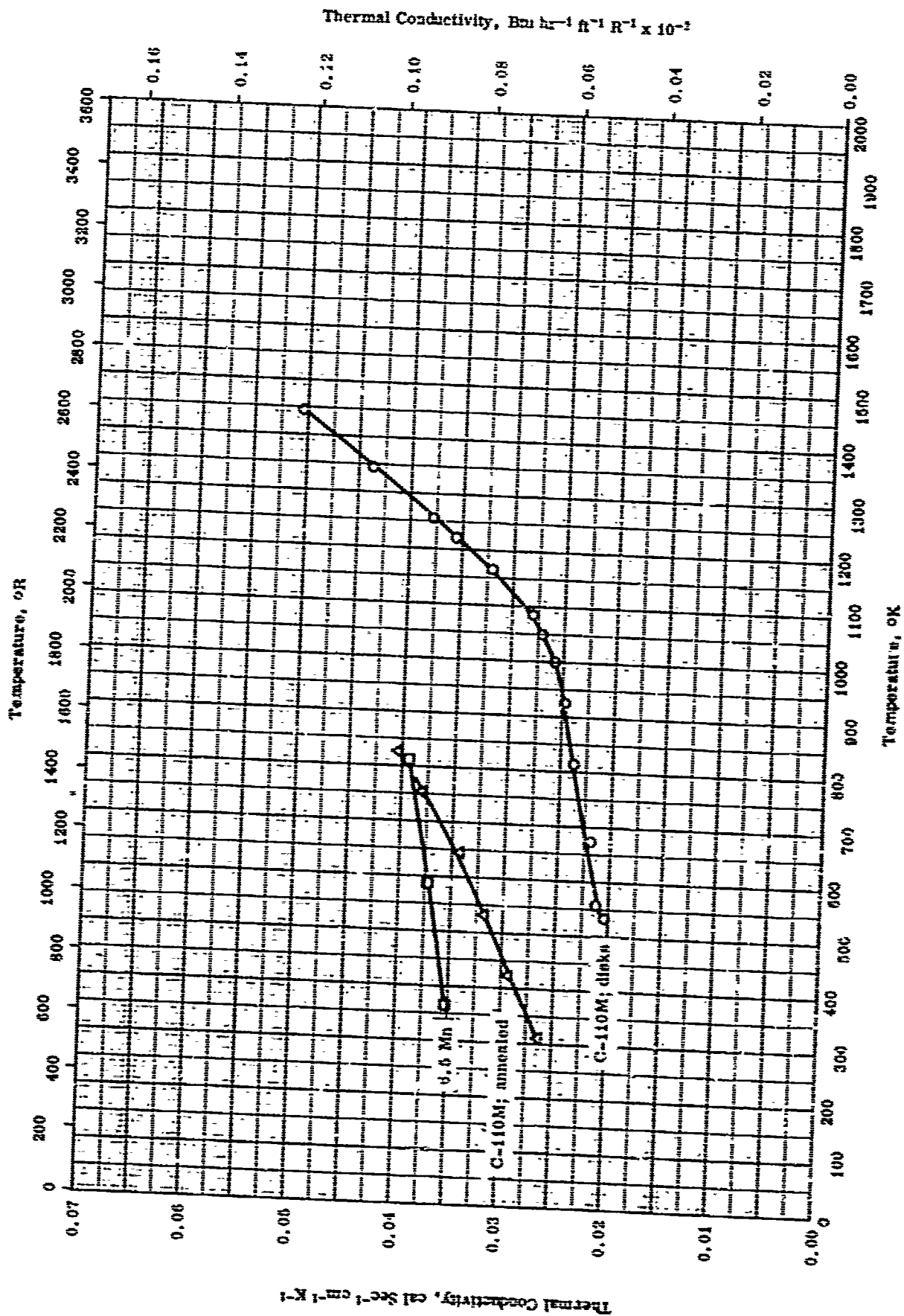


SPECIFIC HEAT -- TITANIUM + MANGANESE

SPECIFIC HEAT -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Sym No | Ref. | Temp. Range, °K | Test Error % | Sample Specifications | Remarks |
|-----------|------|--------------------|-----------------|--|--------------------------|
| O | 61-2 | 497-1810 | 3.0 | Ti-C 110 M; 91.81 Ti, 7.9 Mn, 0.15 O ₂ , 0.03 C, and 0.01 W; density 286 lb ft ⁻³ . | Under helium atmosphere. |



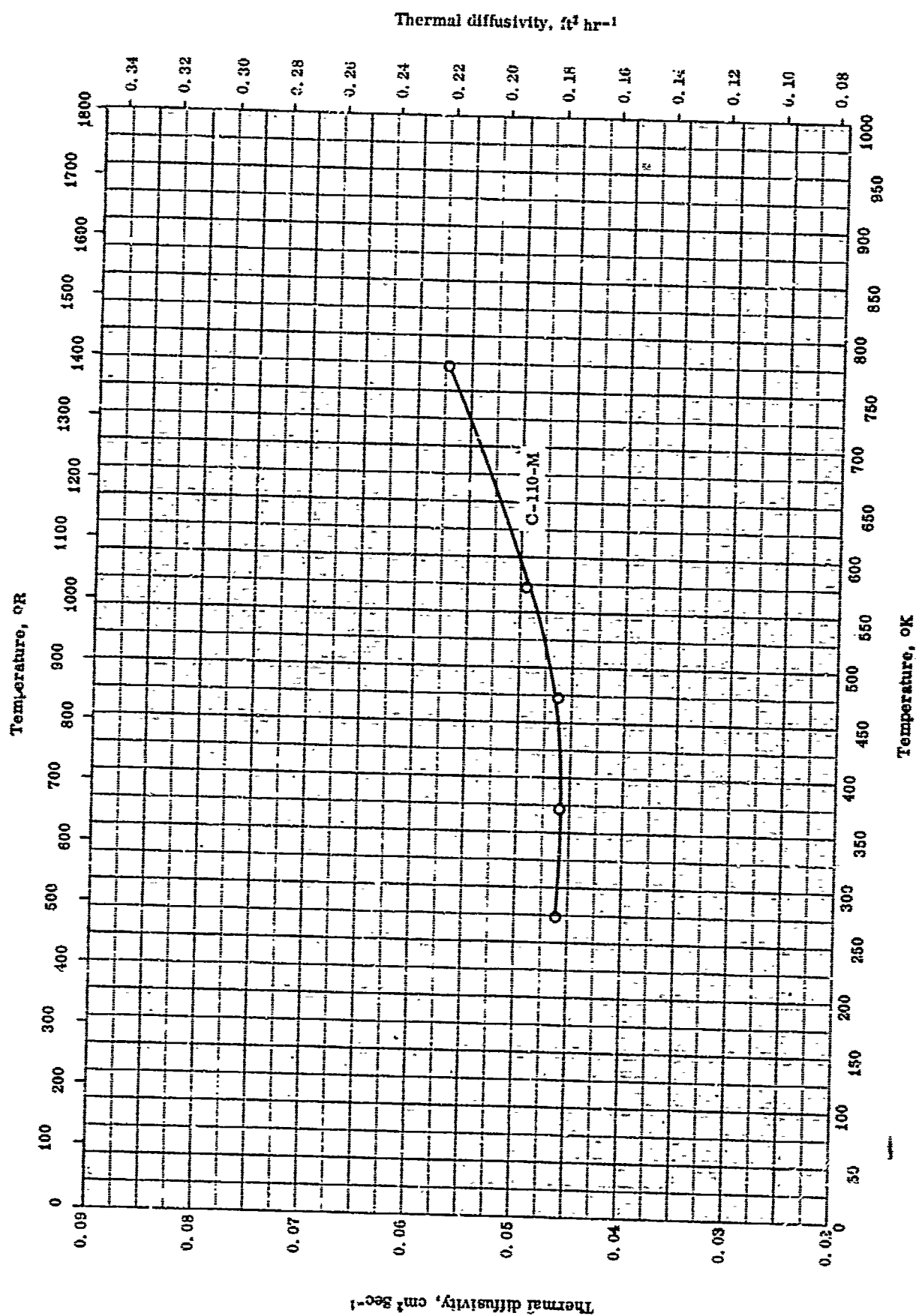
THERMAL CONDUCTIVITY -- TITANIUM + MANGANESE

THERMAL CONDUCTIVITY -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| □ | 56-9 | 366-811 | | 93.21 Ti, 6.50 Mn, 0.20 Fe, 0.177 O, 0.05 C, 0.034 N, and 0.0063 H. | In a mild annealed condition. Sample contained 5 one-inch dia disks. |
| △ | 58-14 | 311-828 | ±5 | C-110M (Formerly RC - 130 A); 8 Mn; nominal composition. | |
| ○ | 61-2 | 524-1446 | <5 | Ti C110M; 91.81 Ti, 7.9 Mn, 0.15 O, 0.03 C, and 0.01 W. | |

TPRC

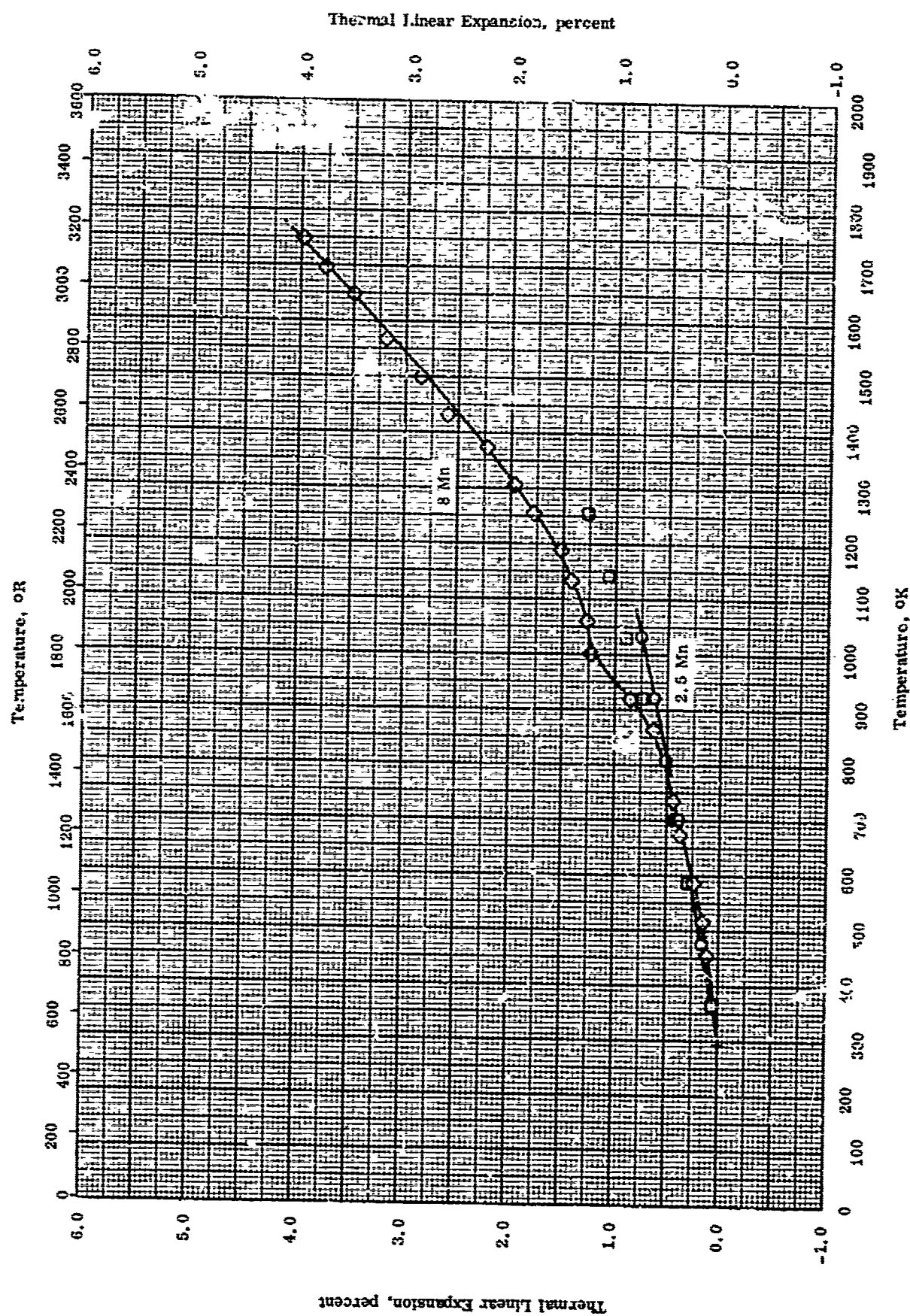


THERMAL DIFFUSIVITY -- TITANIUM + MANGANESE

THERMAL DIFFUSIVITY -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--------------------------|---------|
| O | 56-1 | 273-773 | | C-110-M; 92 Ti and 8 Mn. | |



THERMAL LINEAR EXPANSION -- TITANIUM + MANGANESE

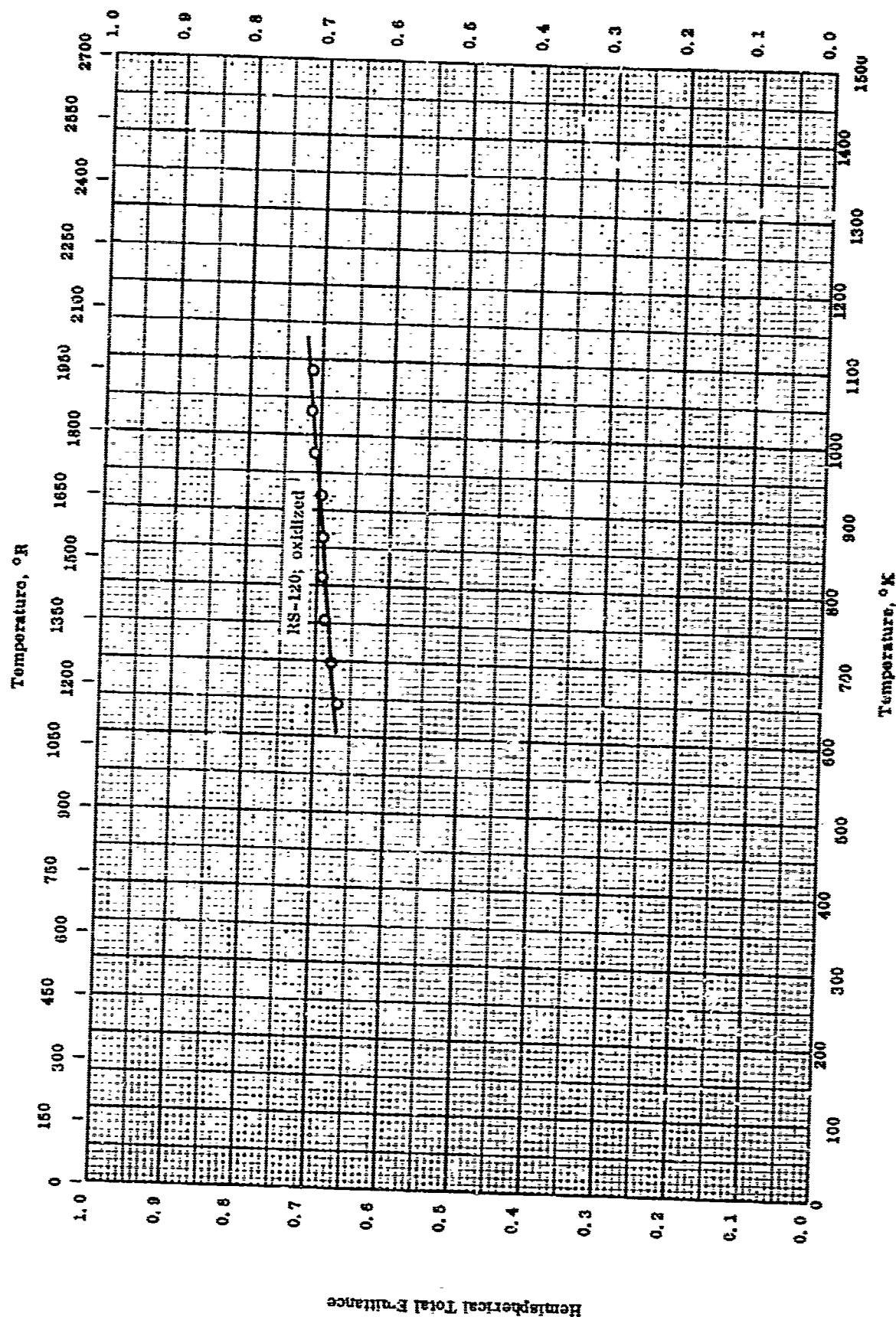
THERMAL LINEAR EXPANSION -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| ○ | 54-33 | 297-1033 | | 2.5 Mn. | |
| □ | 54-35 | 293-1255 | | RC - 330A (C110M); 8 Mn; density 0.172 lb in ⁻³ . | |
| ◇ | 61-2 | 300-1748 | | Titanium C110M; 91.81 Ti, 7.9 Mn, 0.15 O, 0.03 C, 0.01 W; density 4.59 g cm ⁻³ . | |
| △ | 63-29 | 293-811 | | 8 Mn; density 4.73 g cm ⁻³ ; alpha-beta alloy. | |

Hemispherical Total Emittance

531



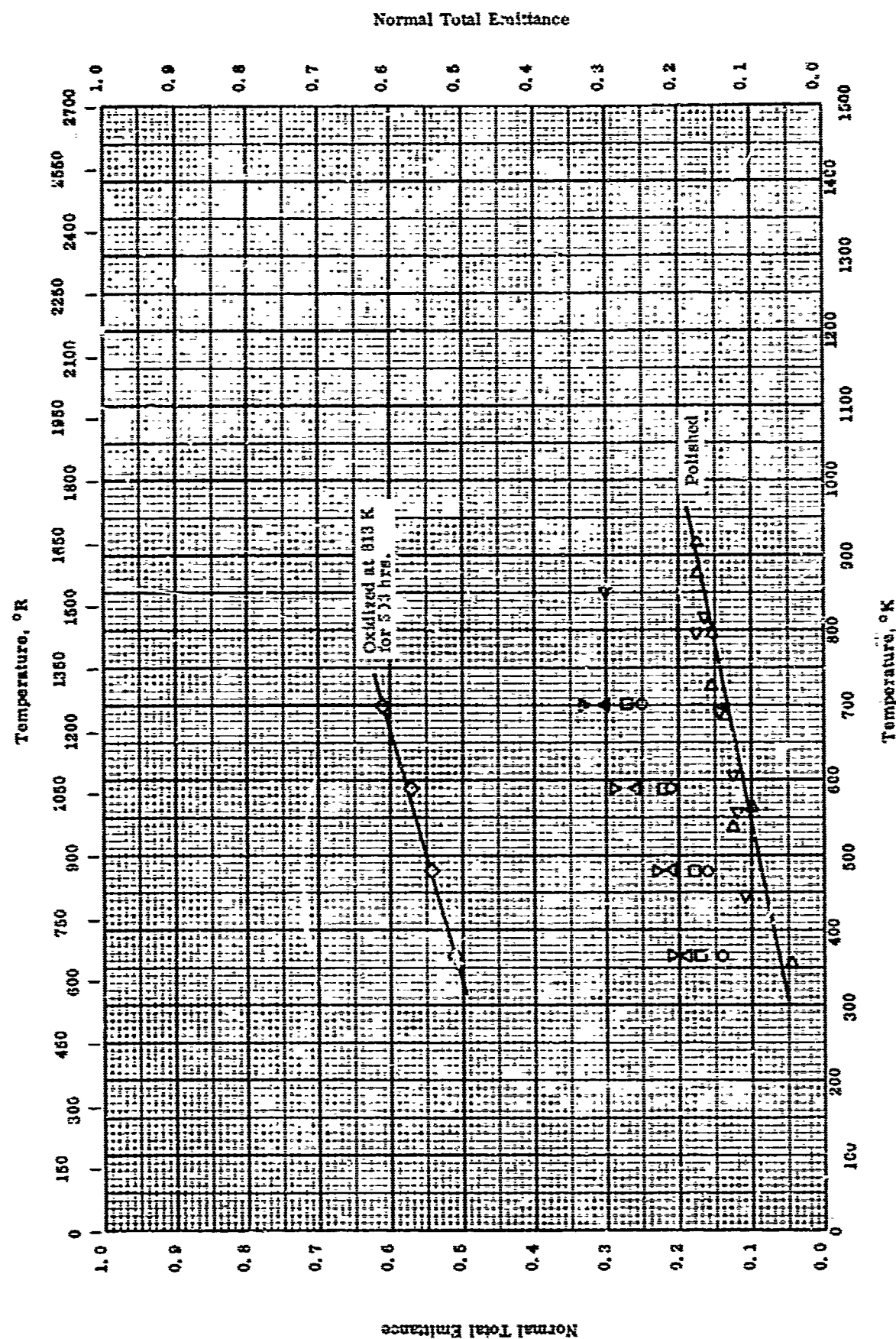
HEMISPHERICAL TOTAL EMITTANCE -- TITANIUM + MANGANESE

TPRC

HEMISPHERICAL TOTAL EMITTANCE -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Spec No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|-------|-------------------|------------------|-----------------------|---|
| 0 | 58-24 | 644-1089 | > 2 | RS-120. | Stably oxidized in quiescent air at 1089 K. |

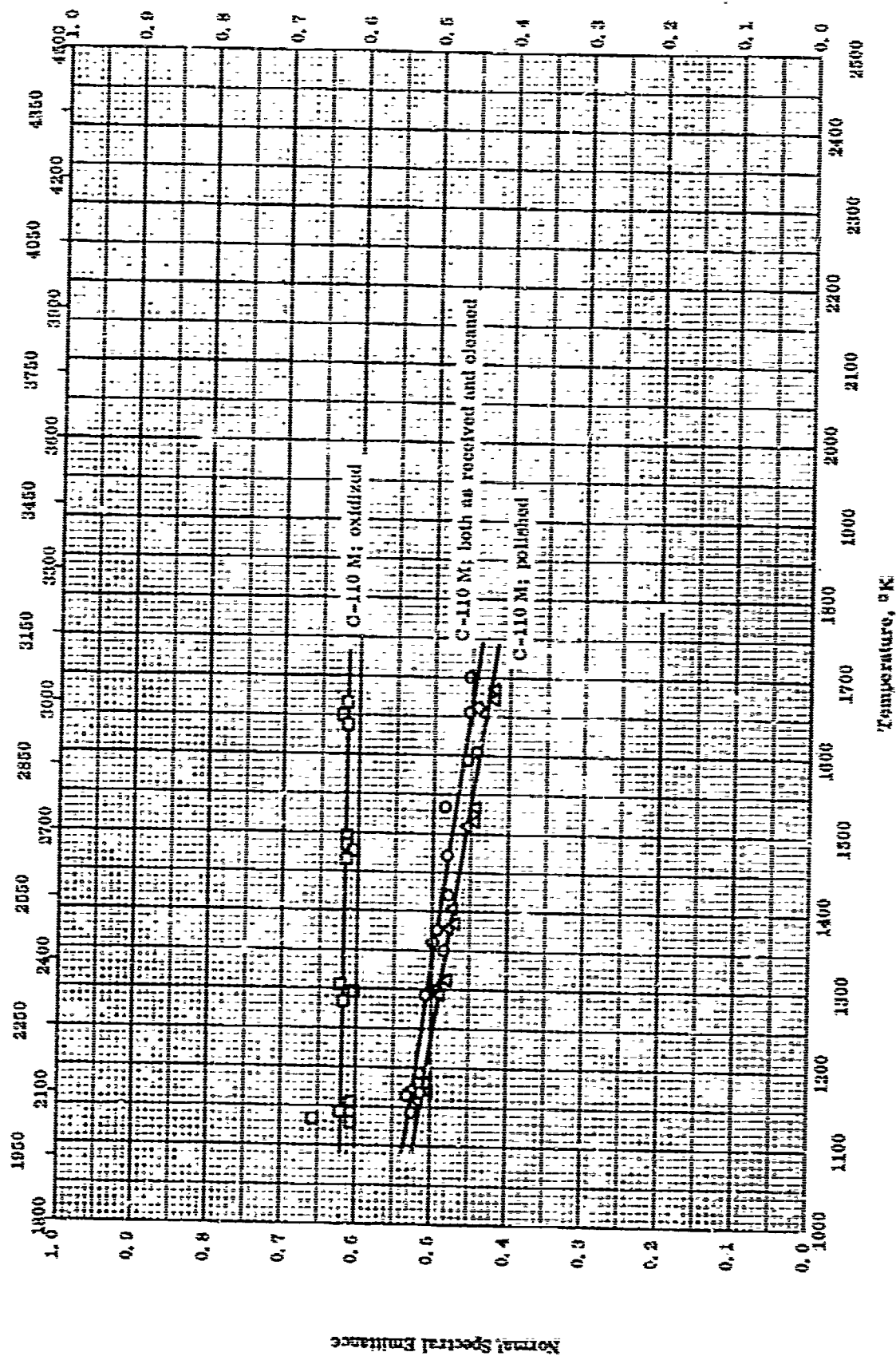


NORMAL TOTAL EMITTANCE -- TITANIUM + MANGANESE
(C-110M, AMS 4908)

NORMAL TOTAL EMITTANCE -- TITANIUM + MANGANESE
(C-110M, AMS 4908)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 58-26 | 360-700 | ± 21 | C-110M, AMS 4908. | Oxidized at 680 K for 306 hrs. |
| □ | 58-26 | 360-700 | ± 18 | C-110M, AMS 4908. | Oxidized at 705 K for 100 hrs. |
| △ | 58-26 | 360-700 | ± 16 | C-110M, AMS 4908. | Oxidized at 711 K for 306 hrs. |
| ▽ | 58-26 | 360-700 | ± 14 | C-110M, AMS 4908. | Oxidized at 813 K for 303 hrs. |
| ◇ | 58-20 | 360-700 | ± 6 | C-110M, AMS 4908. | Measured in vacuum (5×10^{-4} mm Hg); same data for as received, cleaned (with a liquid detergent) and polished (with fine polishing compound). |
| ▷ | 57-18 | 350-910 | ± 10 | C-110M, AMS 4908. | Oxidized in air at red heat for 30 min.; measured in vacuum (5×10^{-4} mm Hg). |
| ◁ | 57-18 | 444-850 | ± 10 | C-110M, AMS 4908. | |



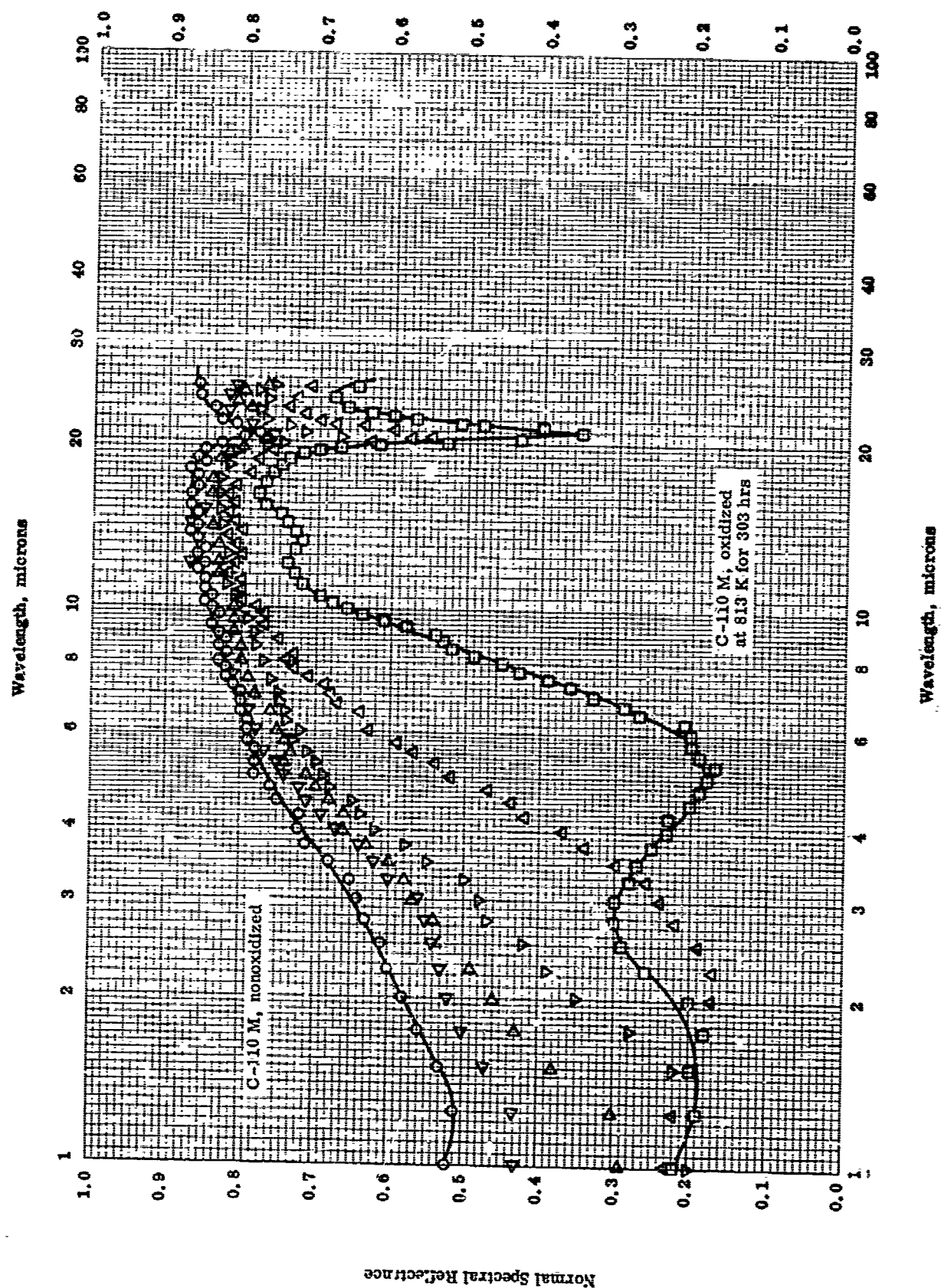
NORMAL SPECTRAL EMITTANCE - TITANIUM + MANGANESE

NORMAL SPECTRAL EMITTANCE -- TITANIUM + MANGANESE

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. ^o K Range | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|---------------------|-------------------------------|------------------|-----------------------|---|
| O | 57-48 | 0.665 | 1144-1700 | | C-110 M. | Measured in vacuum; same data for as re- ceived and cleaned (with a liquid detergent). |
| Δ | 57-48 | 0.665 | 1158-1686 | | C-110 M. | Polished with fine polishing compounds; measured in vacuum. |
| \square | 57-48 | 0.665 | 1130-1666 | | C-110 M. | Oxidized in air at red heat for 30 min.; measured in vacuum. |

TPRC



NORMAL SPECTRAL REFLECTANCE -- TITANIUM + MANGANESE

NORMAL SPECTRAL REFLECTANCE -- TITANIUM + MANGANESE

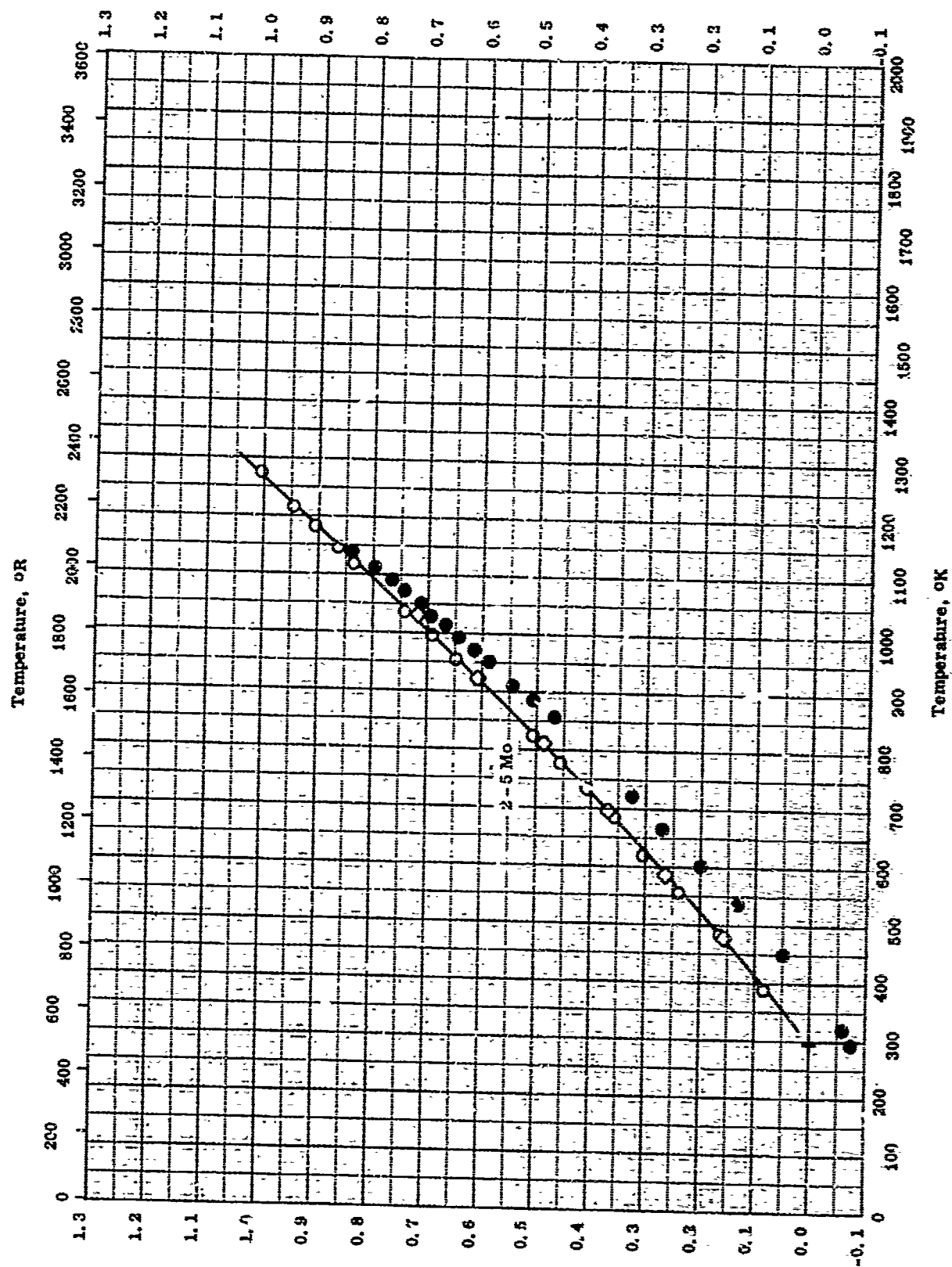
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. °K | Wavelength Range, μ | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|----------|------------------------|-----------------|-----------------------|--------------------------------|
| ○ | 58-26 | 310.9 | 1.0-25.0 | | C-110 M, AMS 4908 | Oxidized at 813 K for 303 hrs. |
| □ | 58-26 | 310.9 | 1.0-25.0 | | C-110 M, AMS 4908 | Oxidized at 739 K for 303 hrs. |
| △ | 58-26 | 310.9 | 1.0-25.0 | | C-110 M, AMS 4908 | Oxidized at 711 K for 306 hrs. |
| ▽ | 58-26 | 310.9 | 1.0-25.0 | | C-110 M, AMS 4908 | Oxidized at 705 K for 100 hrs. |
| △ | 58-26 | 310.9 | 1.0-25.0 | | C-110 M, AMS 4908 | Oxidized at 580 for 306 hrs. |
| ▽ | 58-26 | 310.9 | 1.0-25.0 | | C-110 M, AMS 4908 | |

TPRC

Thermal Linear Expansion, percent

539



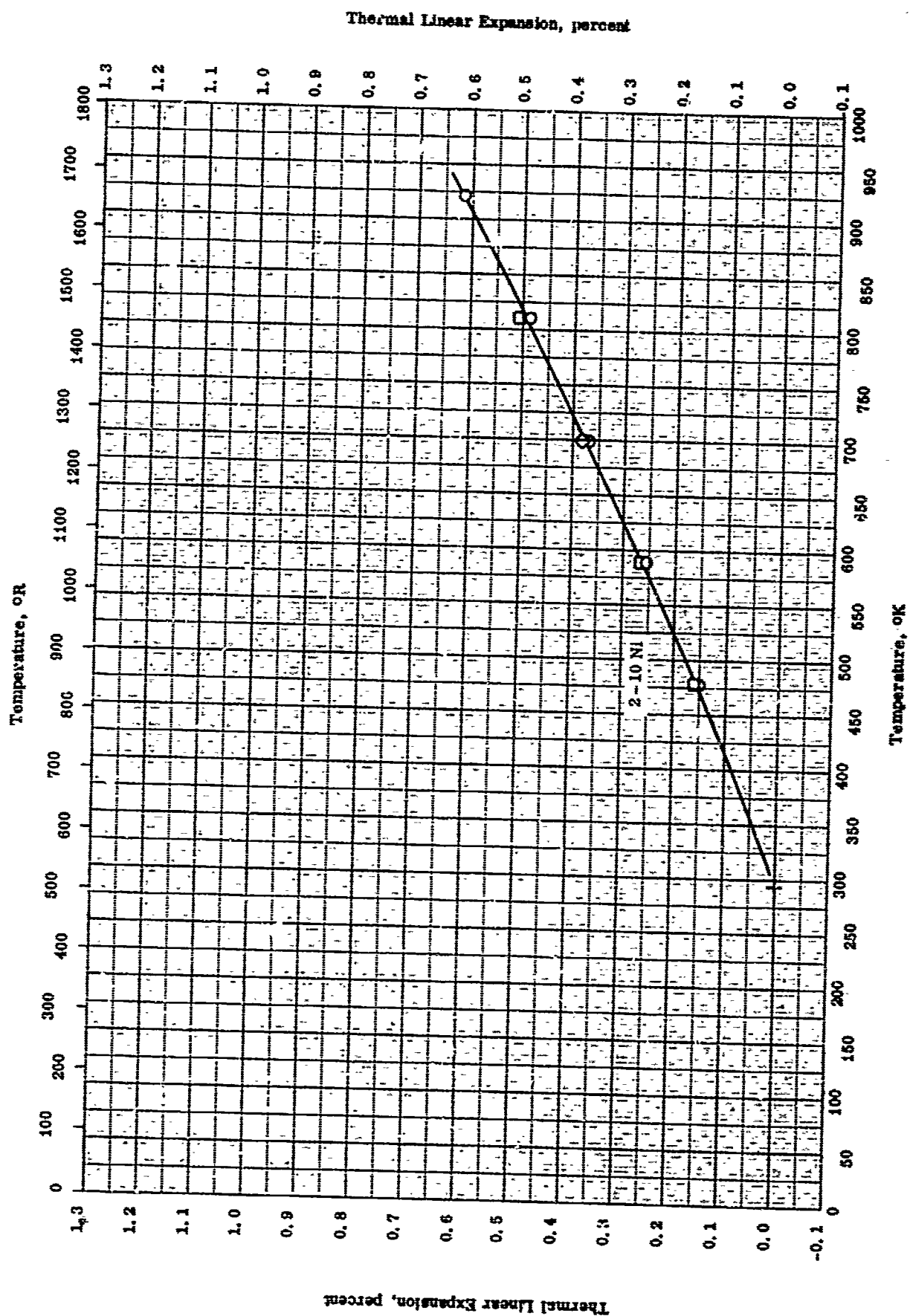
THERMAL LINEAR EXPANSION -- TITANIUM + MOLYBDENUM

TPRC

THERMAL LINEAR EXPANSION -- TITANIUM-MOLYBDENUM

REFERENCE INFORMATION

| Sym- bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|-------|-------------------|------------------|-----------------------|---|
| ◇ | 54-33 | 297-1033 | | 5.0 Mo. | Heat treated for 4 hrs in high vacuum at 1200 C; measured in vacuum of 10^{-5} mm Hg with a heat- ing rate of 1 C min ⁻¹ ; phase transition occurred at about 800 C. Cooling curve of above specimen with a cooling rate of 18 C min ⁻¹ ; permanent change in length -0.08% resulted. |
| ○ | 64-12 | 298-1275 | | 2.0 Mo. | |
| ● | 64-12 | 293-1275 | | 2.0 Mo. | |



THERMAL LINEAR EXPANSION -- TITANIUM + NICKEL

THERMAL LINEAR EXPANSION -- TITANIUM + NICKEL

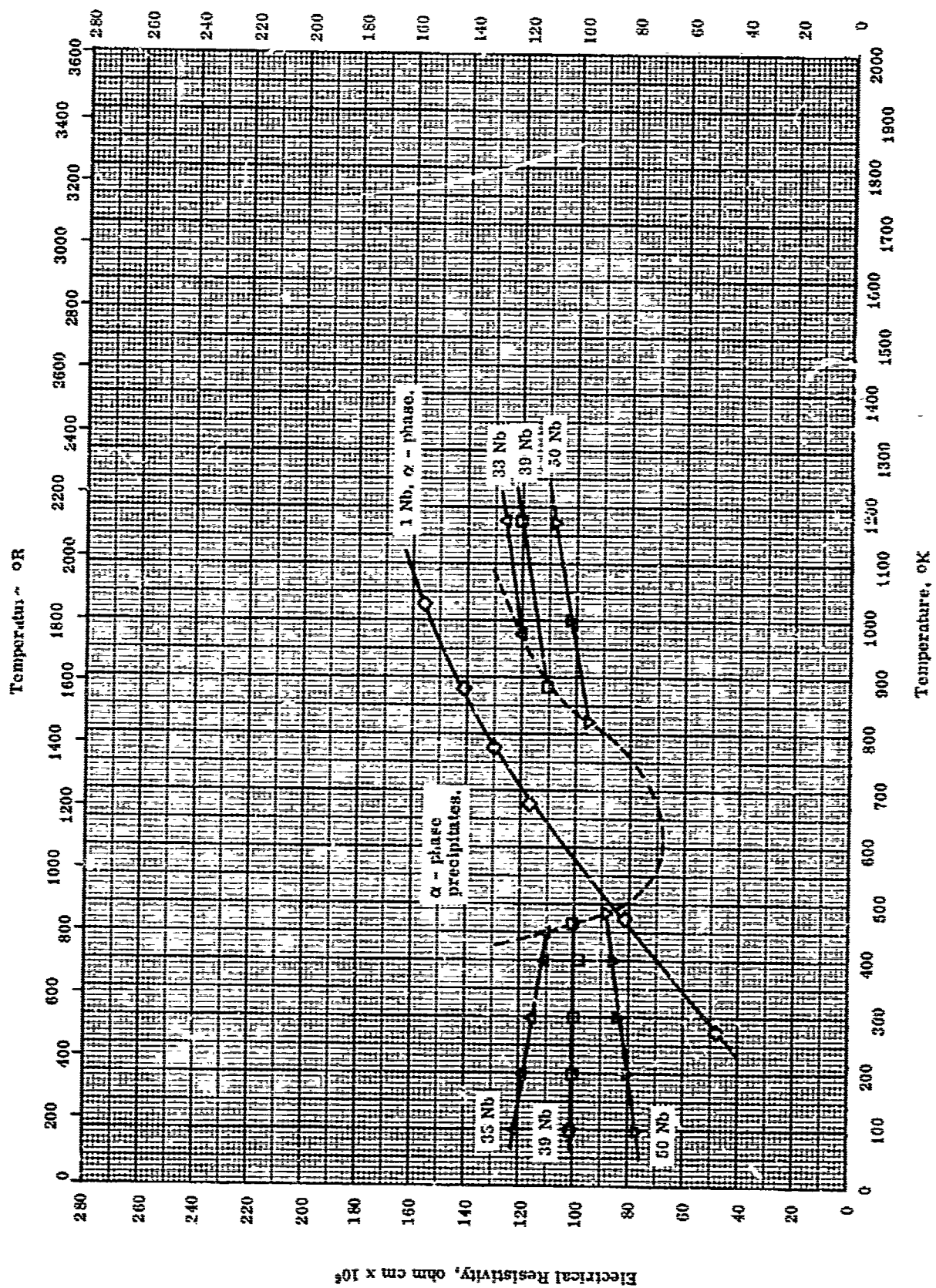
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 54-33 | 297-022 | | 2.5 NI. | |
| □ | 54-33 | 297-811 | | 7.5 NI. | |
| ◇ | 54-33 | 297-811 | | 10.0 NI. | |

TPRC

Electrical Resistivity, ohm cm x 10⁶

543



ELECTRICAL RESISTIVITY -- TITANIUM + NIOBIUM

TPRC

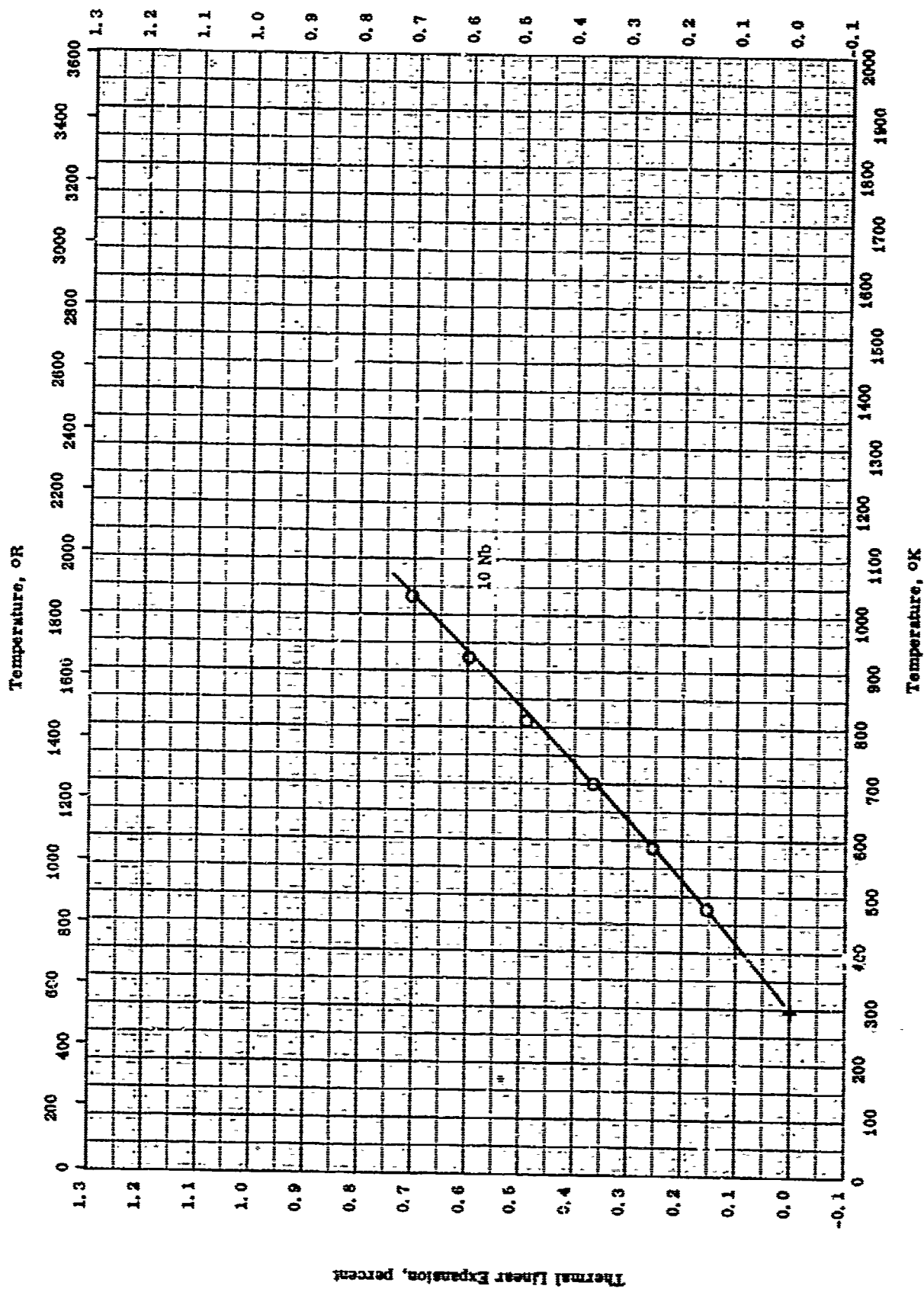
ELECTRICAL RESISTIVITY -- TITANIUM + NIOBIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ▽ | 54-16 | 100-1173 | | 50 Ti and 50 Nb; β - phase; prepared from spectroscopically pure Nb and iodide refined Ti (0.2 atomic % Zr). | Cast, rolled, remelted, hot forged, surface layers removed, cold swaged; homogenized 70 hrs at 1050 °C in vacuum, and quenched to retain β phase; tested in vacuum. |
| □ | 54-16 | 100-1173 | | 60.7 Ti and 39.3 Nb; β - phase; raw materials same as above. | Same as above. |
| △ | 54-16 | 100-1173 | | 67.3 Ti and 32.7 Nb; β - phase; raw materials same as above. | Same as above. |
| ◇ | 56-18 | 273-1023 | ± 1 | 99 Ti and 1 Nb; α - phase; prepared from spectroscopically pure Nb and iodide refined Ti. | Tested in vacuum; anisotropy may exist. |

Thermal Linear Expansion, percent

545



THERMAL LINEAR EXPANSION -- TITANIUM + NIOBIUM

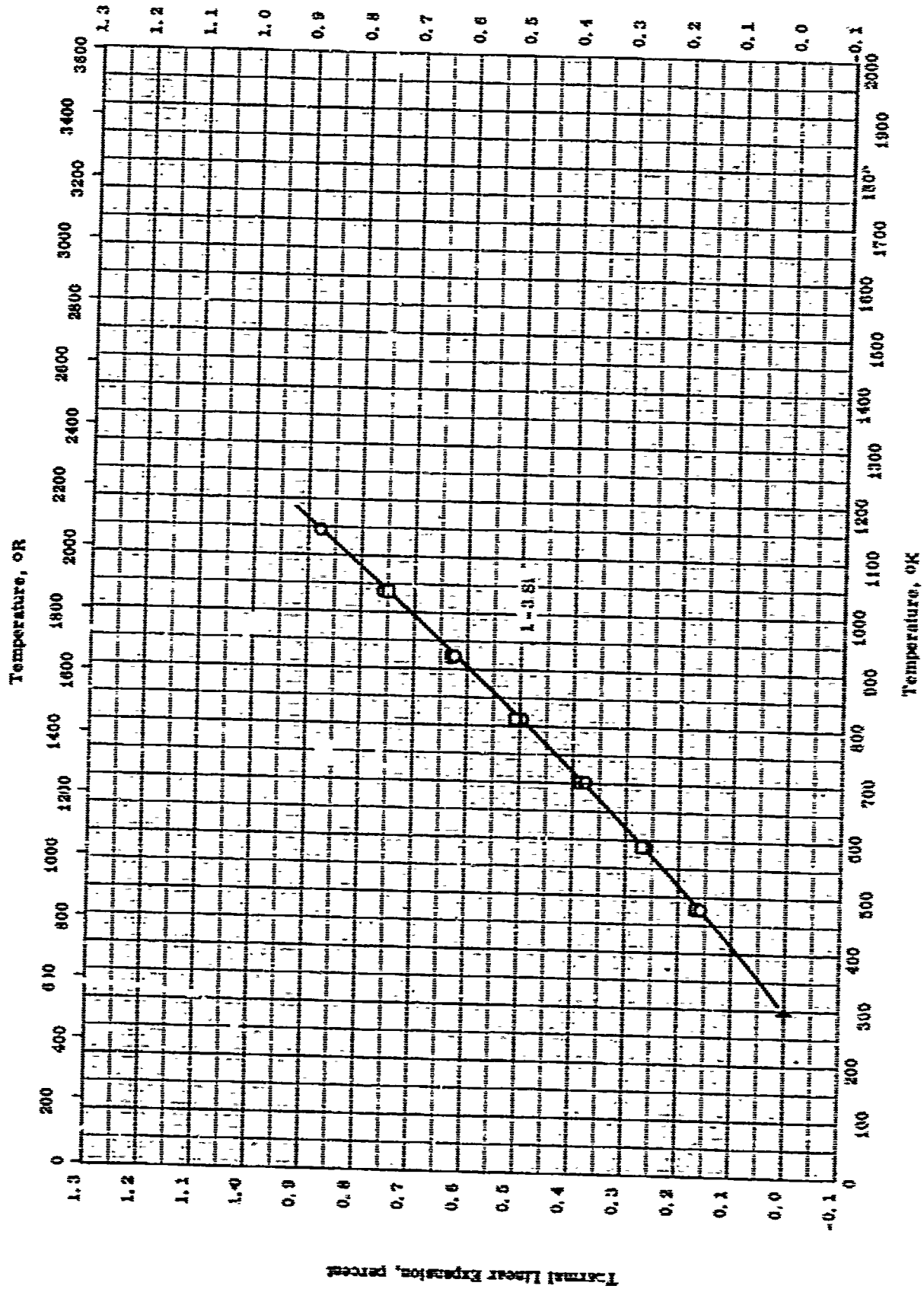
ORC

THERMAL LINEAR EXPANSION -- TITANIUM + NIOBIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| O | 54-33 | 297-1033 | | Iodide Ti and 10 Nb. | |

TPRC



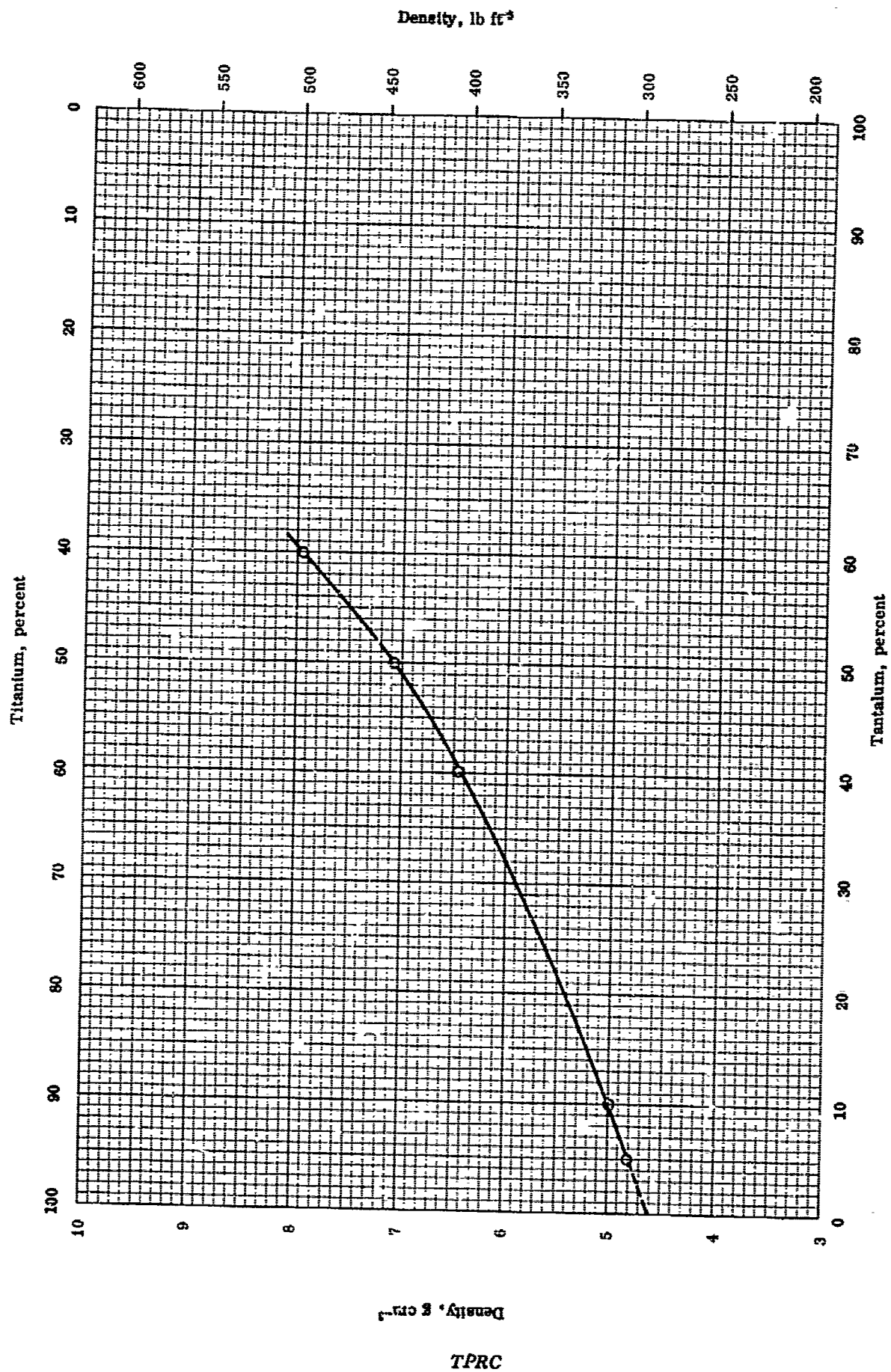
THERMAL LINEAR EXPANSION -- TITANIUM + SILICON

THERMAL LINEAR EXPANSION -- TITANIUM + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 54-33 | 297-1144 | | 3.0 Si. | |
| □ | 54-33 | 297-1144 | | Iodide Ti and 1 Si. | |

TPRC



DENSITY -- TITANIUM + TANTALUM

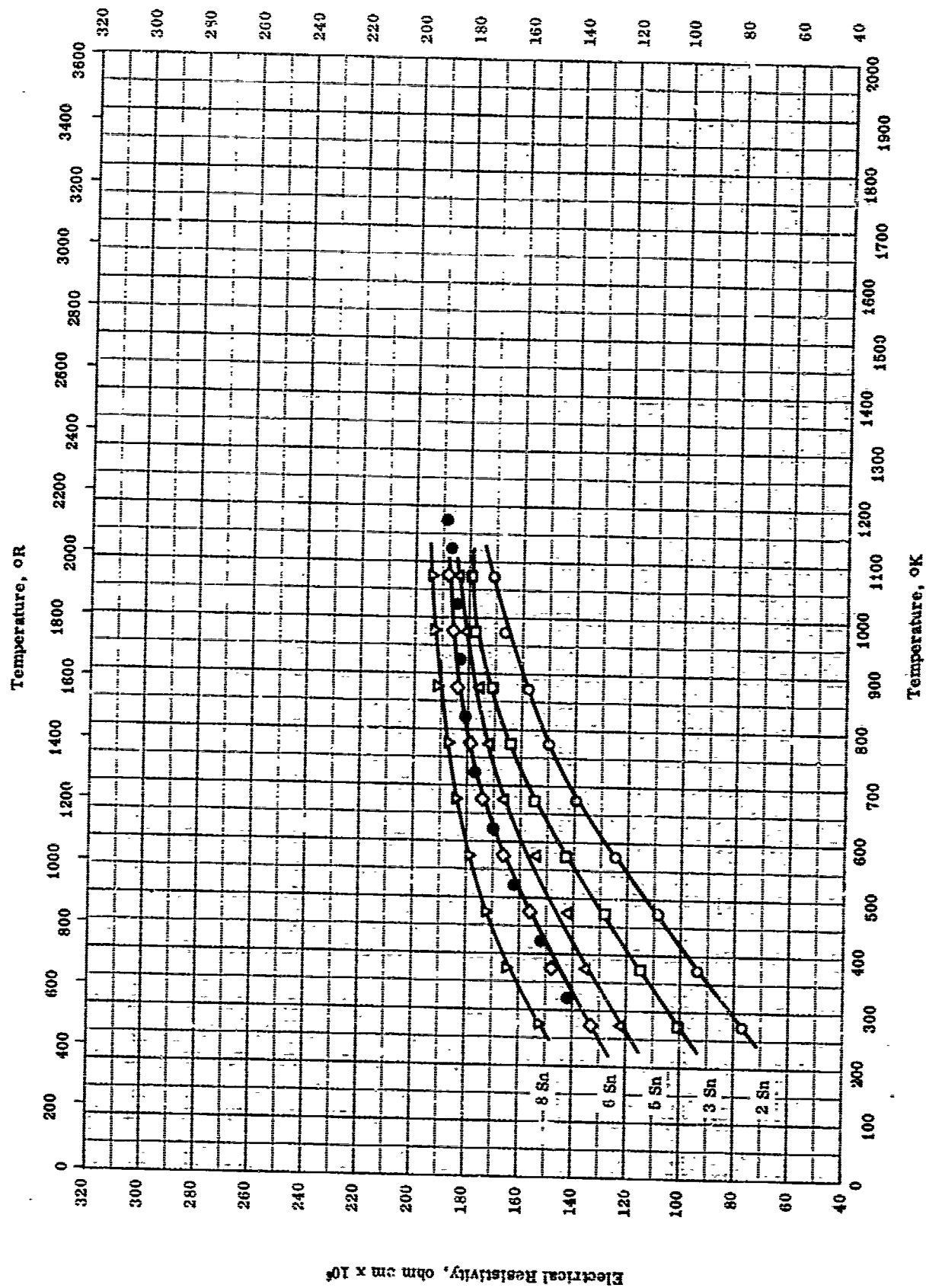
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| O | 54-20 | 298 | | 0-60 Ta. | Density by weight in air and in water. |

TPRC

Electrical Resistivity, ohm cm x 10⁶

551



ELECTRICAL RESISTIVITY -- TITANIUM + TIN

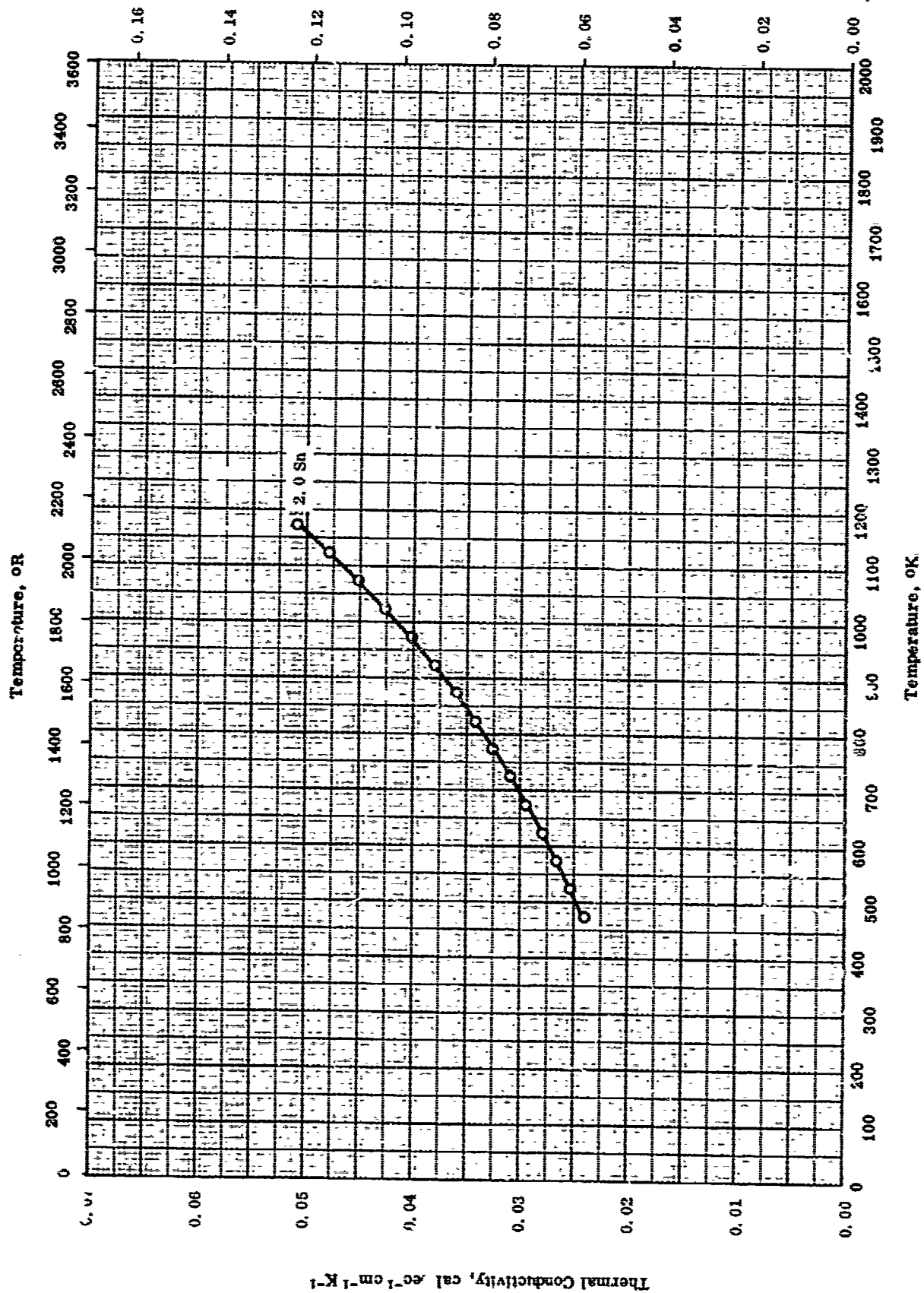
REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 56-18 | 273-1073 | ± 1 | 98 Ti and 2 Sn; α-phase; prepared from iodide refined Ti and 99.99 pure Sn. | Anisotropy may exist; tested in vacuum. |
| □ | 56-18 | 273-1073 | ± 1 | 97 Ti and 3 Sn; α-phase; raw materials same as above. | Same as above. |
| △ | 56-18 | 273-1073 | ± 1 | 95 Ti and 5 Sn; α-phase; raw materials same as above. | Same as above. |
| ◇ | 56-18 | 273-1073 | ± 1 | 94 Ti and 6 Sn; α-phase; raw materials same as above. | Same as above. |
| ▽ | 56-18 | 273-1073 | ± 1 | 92 Ti and 8 Sn; α-phase; raw materials same as above. | Same as above. |
| ● | 61-11 | 323-1173 | | 2, 0 Si. | |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

553



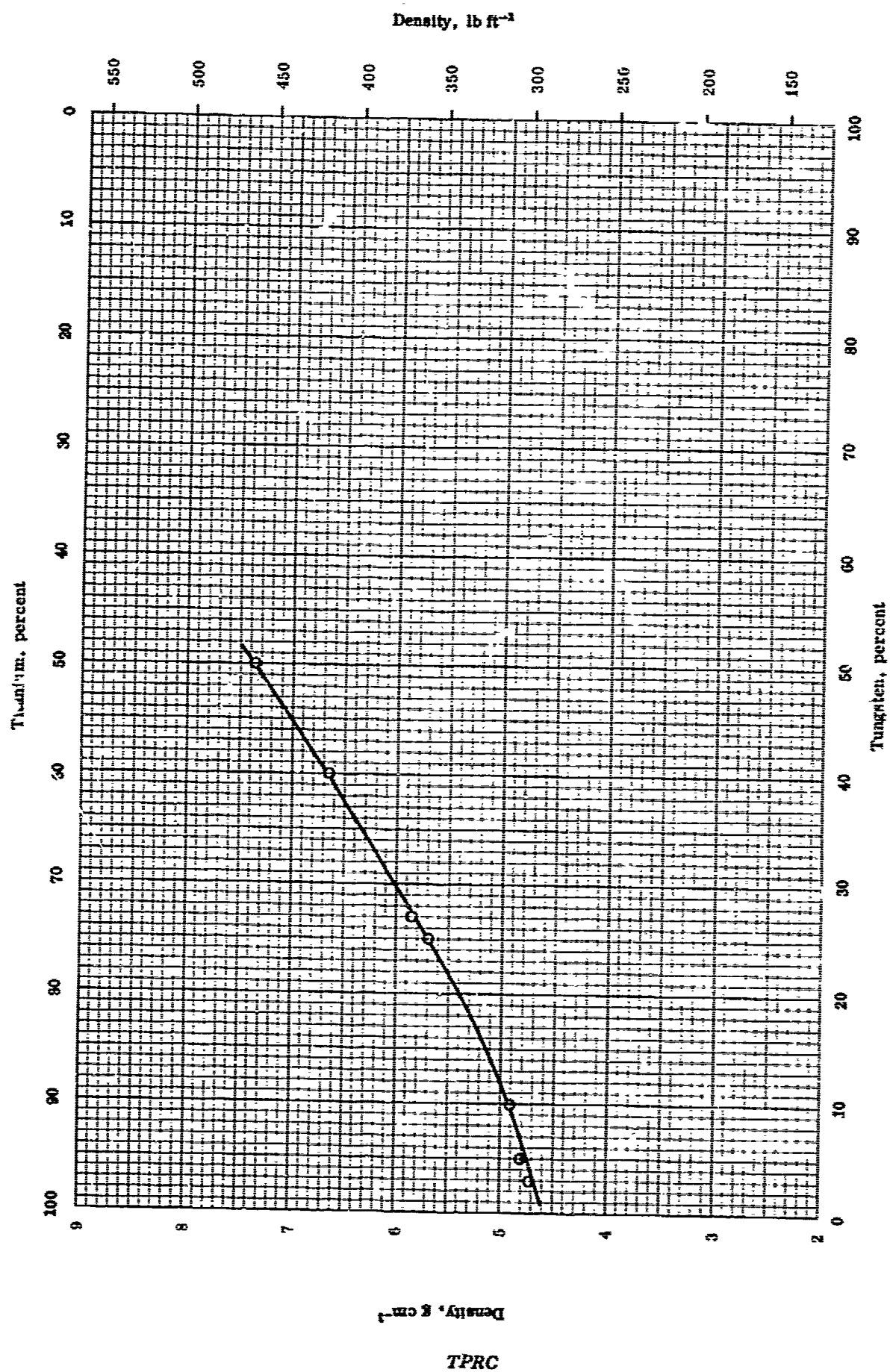
THERMAL CONDUCTIVITY -- TITANIUM + TIN

TPRC

THERMAL CONDUCTIVITY -- TITANIUM + TIN

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| O | 61-11 | 473-1173 | | 2.0 Sn. | |

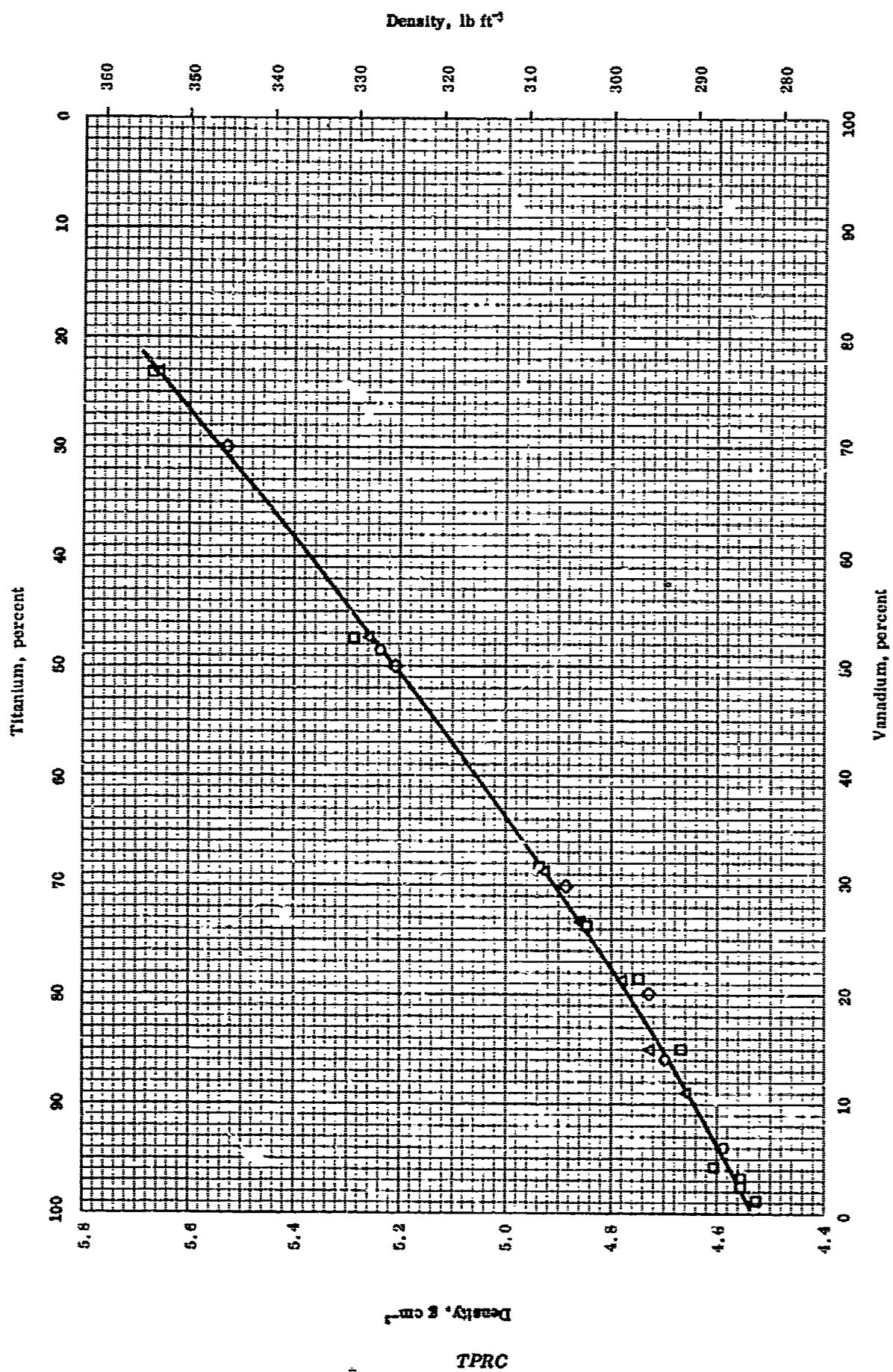


DENSITY -- TITANIUM + TUNGSTEN

DENSITY --- TITANIUM + TUNGSTEN

REFERENCE INFORMATION

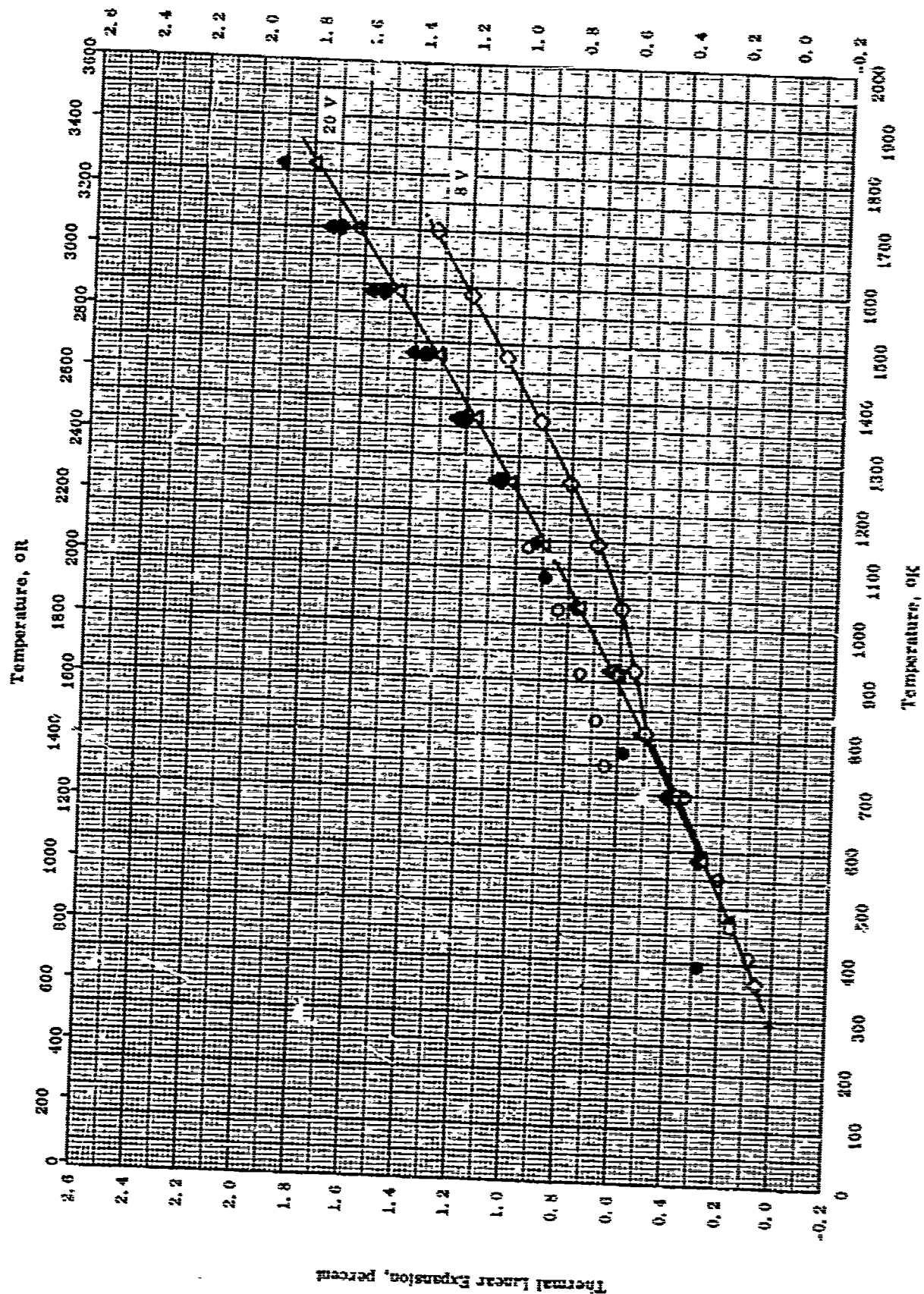
| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| O | 54-20 | 298 | | 0 - 50 W. | Density by weight in air and in water. |



DENSITY -- TITANIUM + VANADIUM

REFERENCE INFORMATION

| Sym bol | Rel. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|-------|--------------------|-------------------|-------------------------|--|
| ○ | 52-12 | 298 | | 0-52 V; 0.4 impurities. | Density by weight in air and in water. |
| □ | 52-12 | 298 | | 0-76 V; 1.2 impurities. | Hot-rolled; same as above. |
| △ | 52-12 | 295 | | 11-76 V; 1.6 impurities | Arc-melted; same as above. |
| ◇ | 52-12 | 298 | | 20-70 V. | Density computed from x-ray measurements of lattice. |



THERMAL LINEAR EXPANSION -- TITANIUM + VANADIUM

THERMAL LINEAR EXPANSION -- TITANIUM + VANADIUM

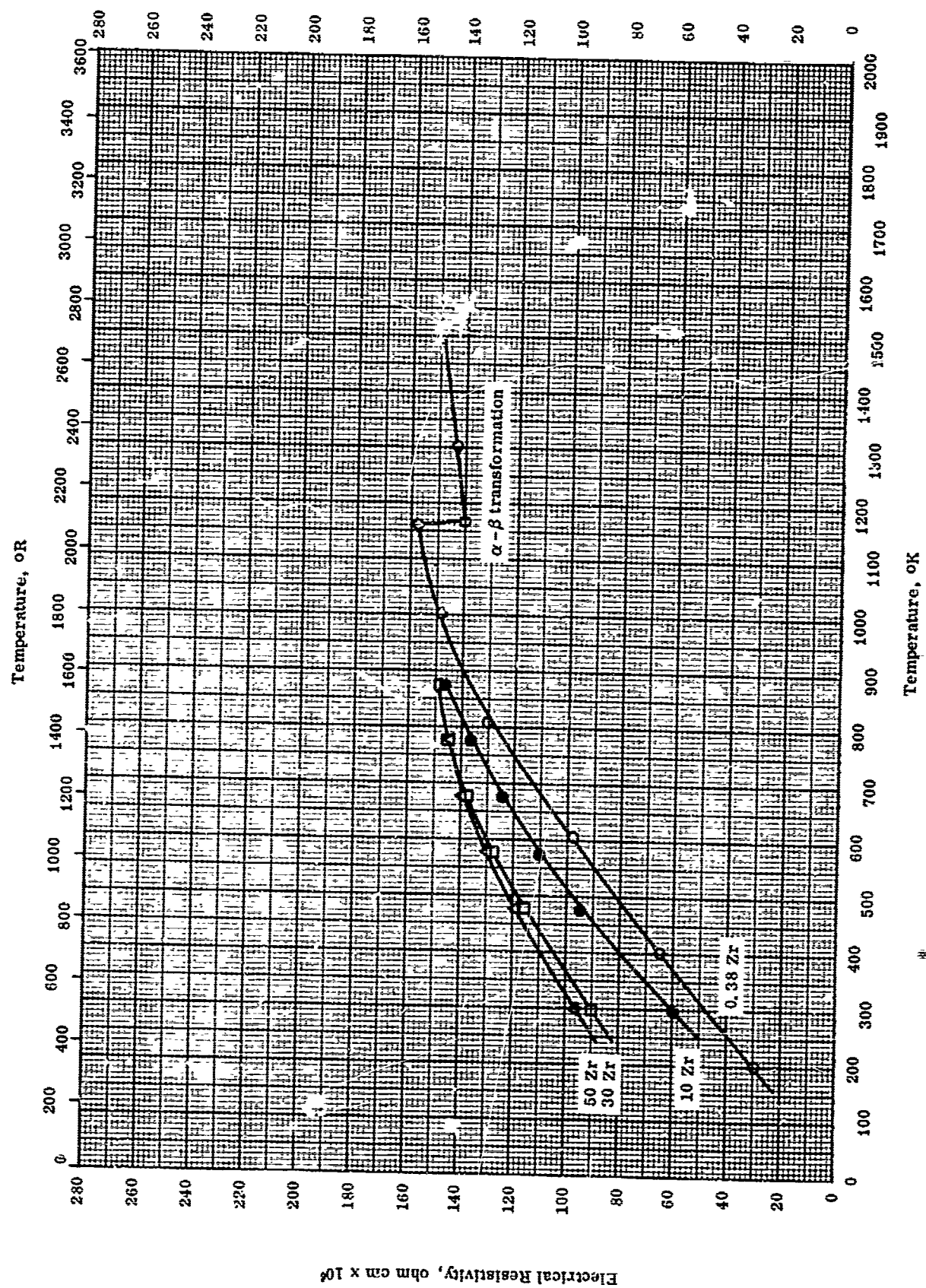
REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Expt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 52-24 | 293-1139 | | 15 V, prepared from 99.8 pure V and 99.9 + pure Ti. | Coil rolled, 21 hrs at 1450 F, and water quenched; tested in vacuum; heating. |
| ● | 52-24 | 393-1139 | | Same as above. | Cooling data of above specimen. |
| □ | 52-24 | 293-1139 | | 10 - 50 V; prepared from 99.8 pure V and 99.9+ pure Ti. | Cast, cold rolled, and vacuum annealed; average of 5 samples with 10, 20, 30, 40, and 50 V respectively; max deviation $\pm 1\%$; tested in vac. |
| ◇ | 61-30 | 293-1700 | | 8 V; prepared from 140 Bhn sponge. | Annealed; measured in vacuum of about 3×10^{-4} mm Hg; heating. |
| ◆ | 61-30 | 293-1700 | | Same as above. | Cooling. |
| △ | 61-30 | 293-1811 | | 20 V; prepared from 140 Bhn sponge. | Annealed; measured in vacuum of about 3×10^{-4} mm Hg; heating. |
| ▲ | 61-30 | 293-1811 | | Same as above. | Cooling. |

TPRC

Electrical Resistivity, ohm cm $\times 10^6$

561



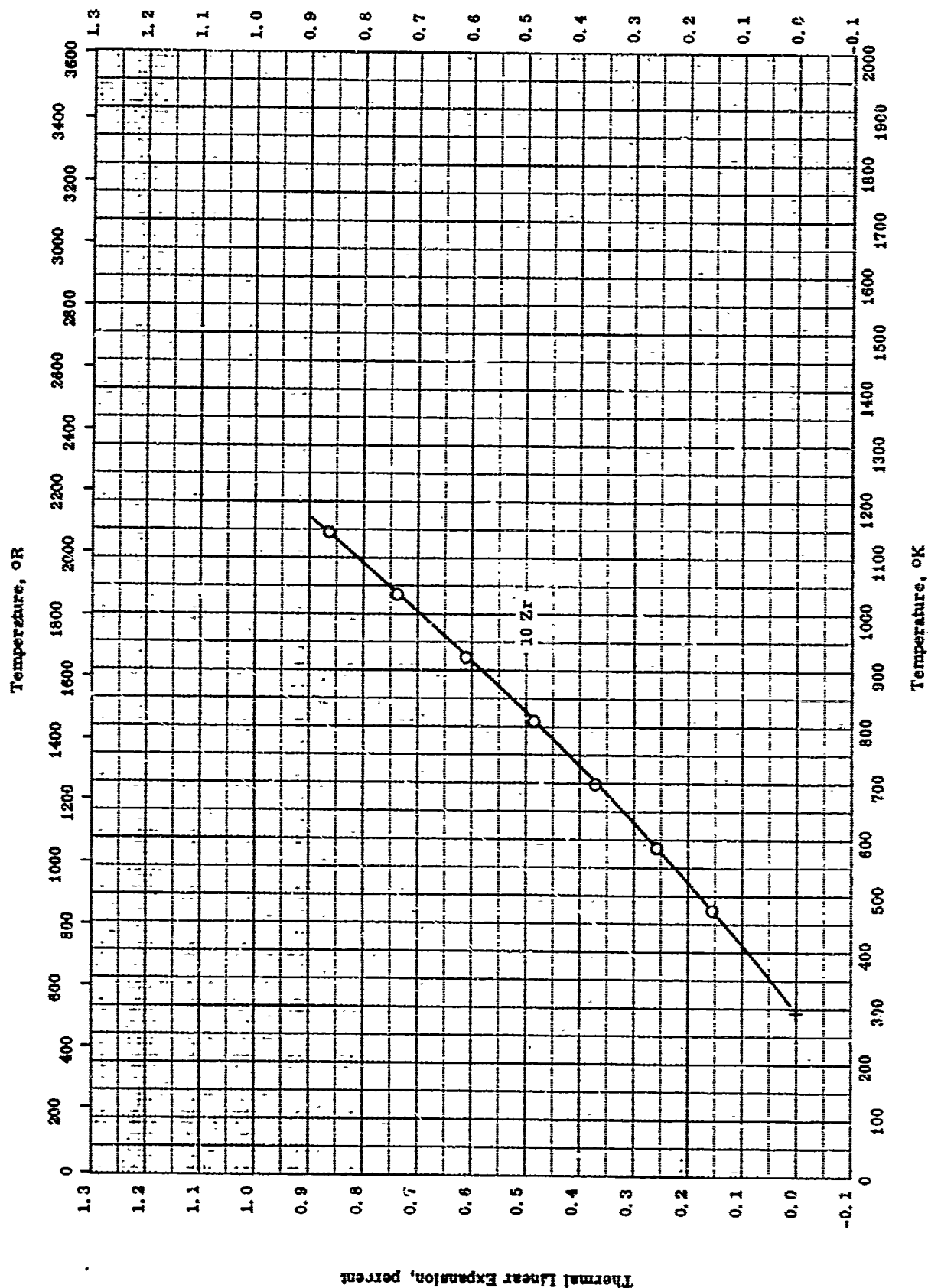
ELECTRICAL RESISTIVITY -- TITANIUM + ZIRCONIUM

TPRC

ELECTRICAL RESISTIVITY -- TITANIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| ● | 56-18 | 298-873 | ± 1 | 90 Ti and 10 Zr; α-phase; prepared from iodide refined Ti and iodide refined Zr (containing ~ 2.5 HF). | |
| □ | 56-18 | 298-873 | ± 1 | 70 Ti and 30 Zr; α-phase; raw materials same as above. | |
| △ | 56-18 | 298-873 | ± 1 | 50 Ti and 50 Zr; α-phase; raw materials same as above. | |
| ○ | 54-16 | 200-1300 | | Iodide titanium; 0.38 Zr. | Homogenized for 70 hrs at 1000 C and then quenched |



THERMAL LINEAR EXPANSION -- TITANIUM + ZIRCONIUM

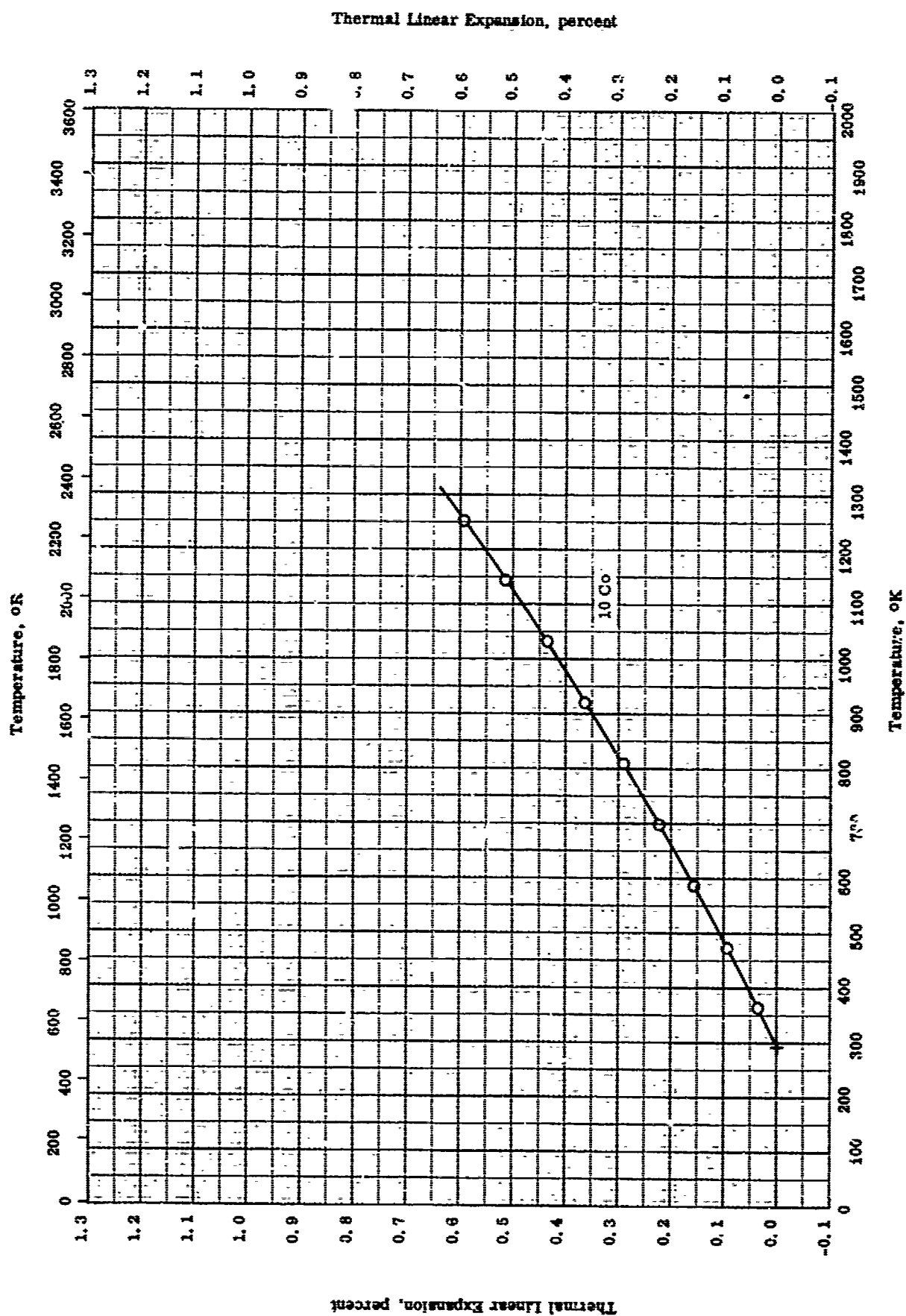
TPRC

THERMAL LINEAR EXPANSION --- TITANIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| O | 54-33 | 297-1144 | | 10.0 %Zr. | |

TPRC



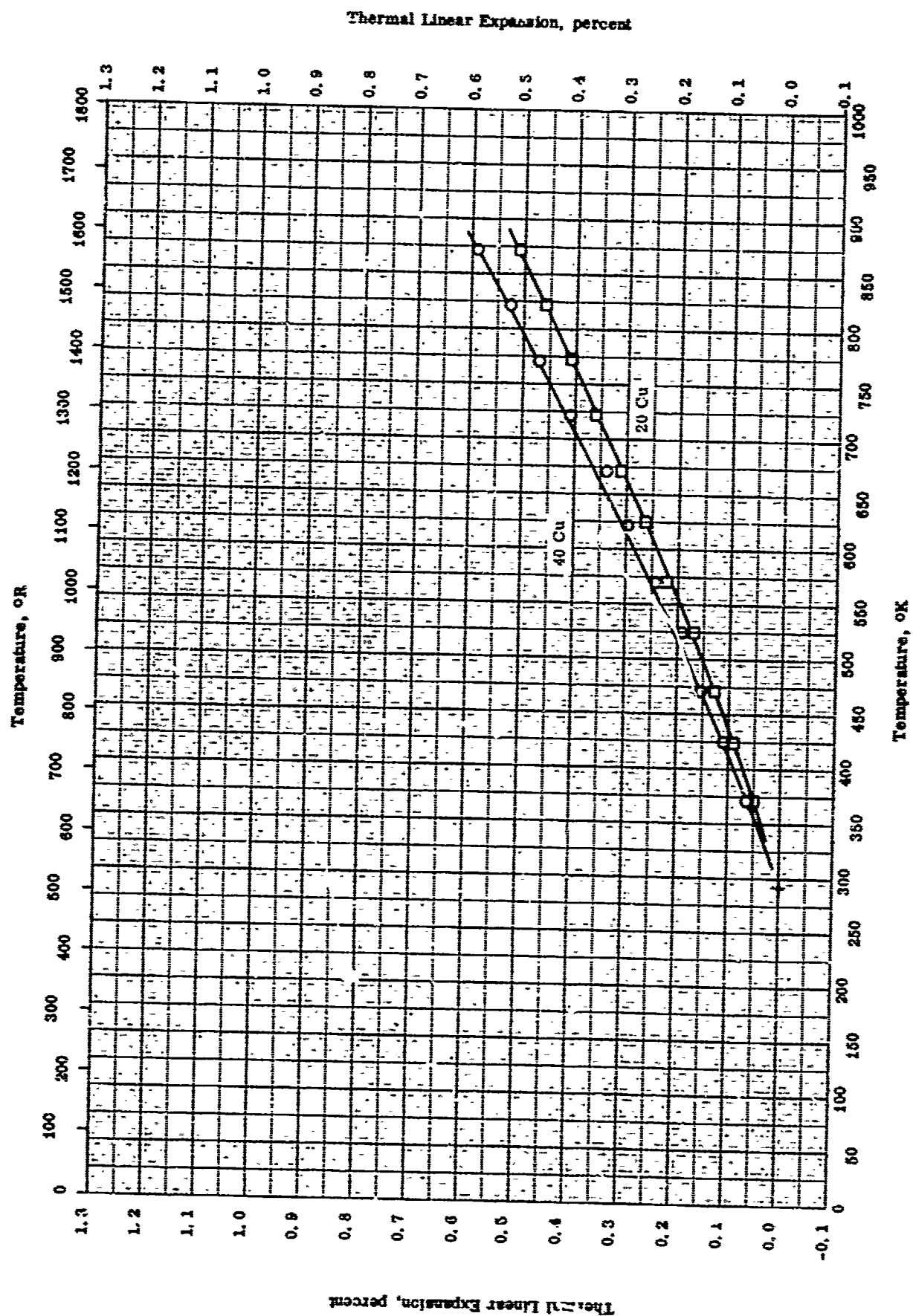
THERMAL LINEAR EXPANSION -- TUNGSTEN + COBALT

THERMAL LINEAR EXPANSION -- TUNGSTEN + COBALT

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range OK | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| O | 63-30 | 293-1255 | | K10; Kennametal Inc.; nominal: 90 W and 10 Co; density 14.38 g cm ⁻³ ; dimension 4 mm dia by 50 mm long. | Furnished machined specimen purchased from Kennametal Inc.; heated in vacuum at about 3 F min ⁻¹ and increased to 5 F min ⁻¹ at the end of heating; no significant permanent change in length observed after test. |

TPRC



THERMAL LINEAR EXPANSION -- TUNGSTEN + COPPER
(Mixtures, not alloy)

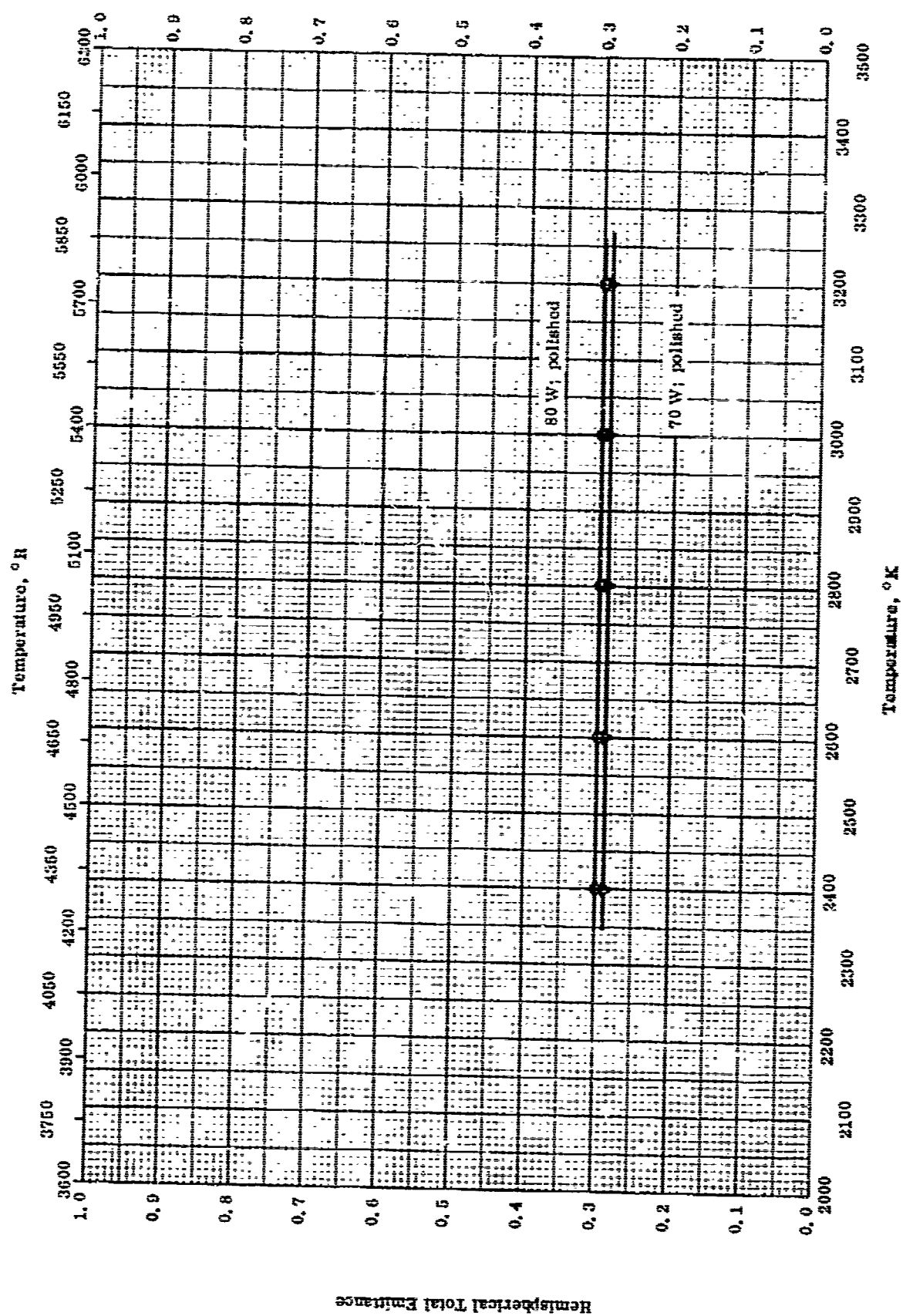
THERMAL LINEAR EXPANSION -- TUNGSTEN + COPPER
(Mixtures, not alloy)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|--------------------|------------------|-----------------------|---------|
| ○ | 42-3 | 293-872 | | 60 W and 40 Cu. | |
| □ | 42-3 | 293-872 | | 80 W and 20 Cu. | |

Hemispherical Total Emittance

569



HEMISPHERICAL TOTAL EMITTANCE -- TUNGSTEN + MOLYBDENUM

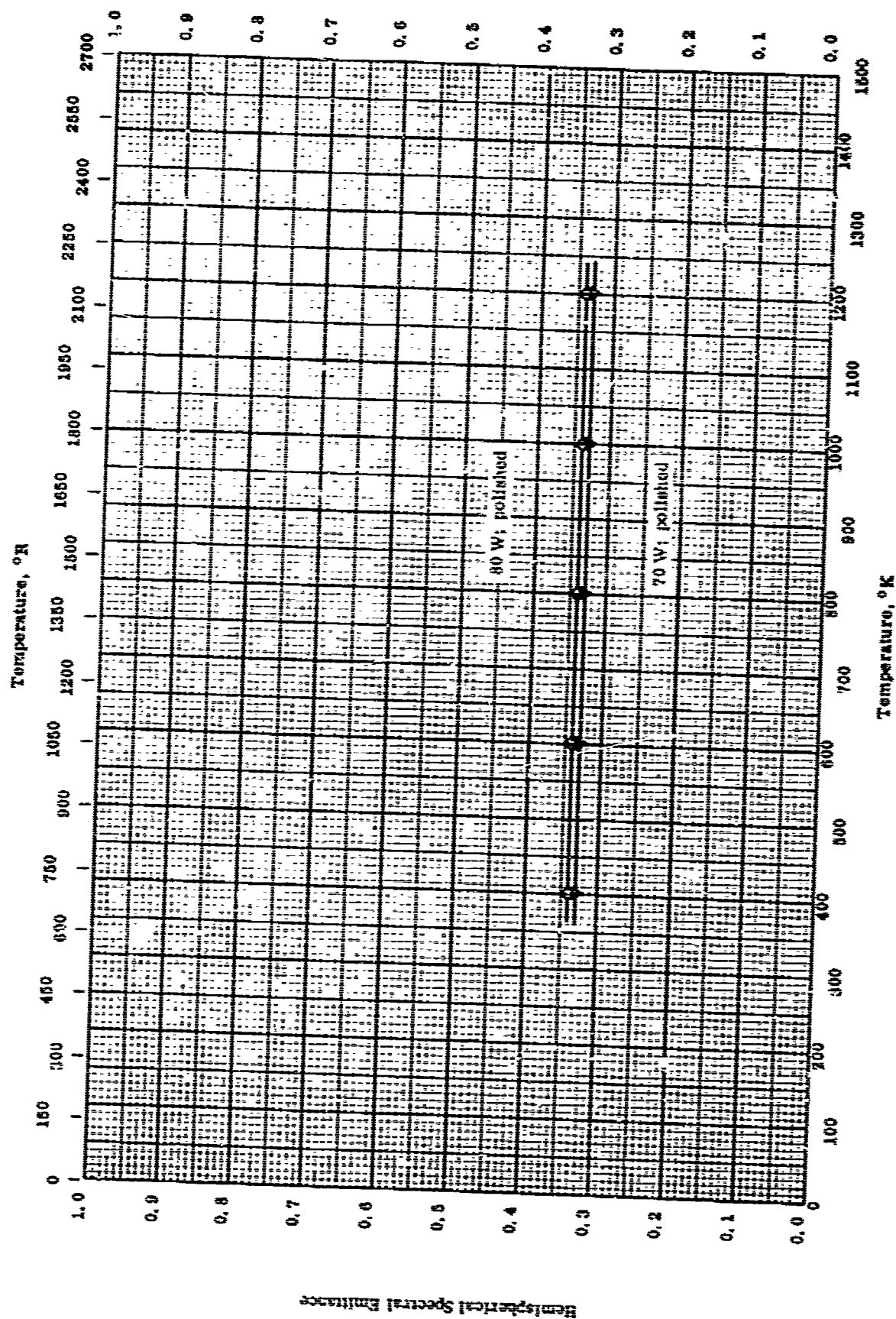
HEMISPHERICAL TOTAL EMITTANCE -- TUNGSTEN + MOLYBDENUM

REFERENCE INFORMATION

| Sym Eol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|--------|-------------------|------------------|-----------------------|---|
| ○ | 62--20 | 2400-3200 | | 80 W and 20 Mo. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000); measured in argon. |
| ▽ | 62-20 | 2400-3200 | | 70 W and 30 Mo. | Polished with abrasive papers (No. 1, 0, 00, 000, and 0000); measured in argon. |

Hemispherical Spectral Emittance

571



HEMISPHERICAL SPECTRAL EMITTANCE — TUNGSTEN + MOLYBDENUM

TPRC

HEMISPHERICAL SPECTRAL EMITTANCE -- TUNGSTEN + MOLYBDENUM

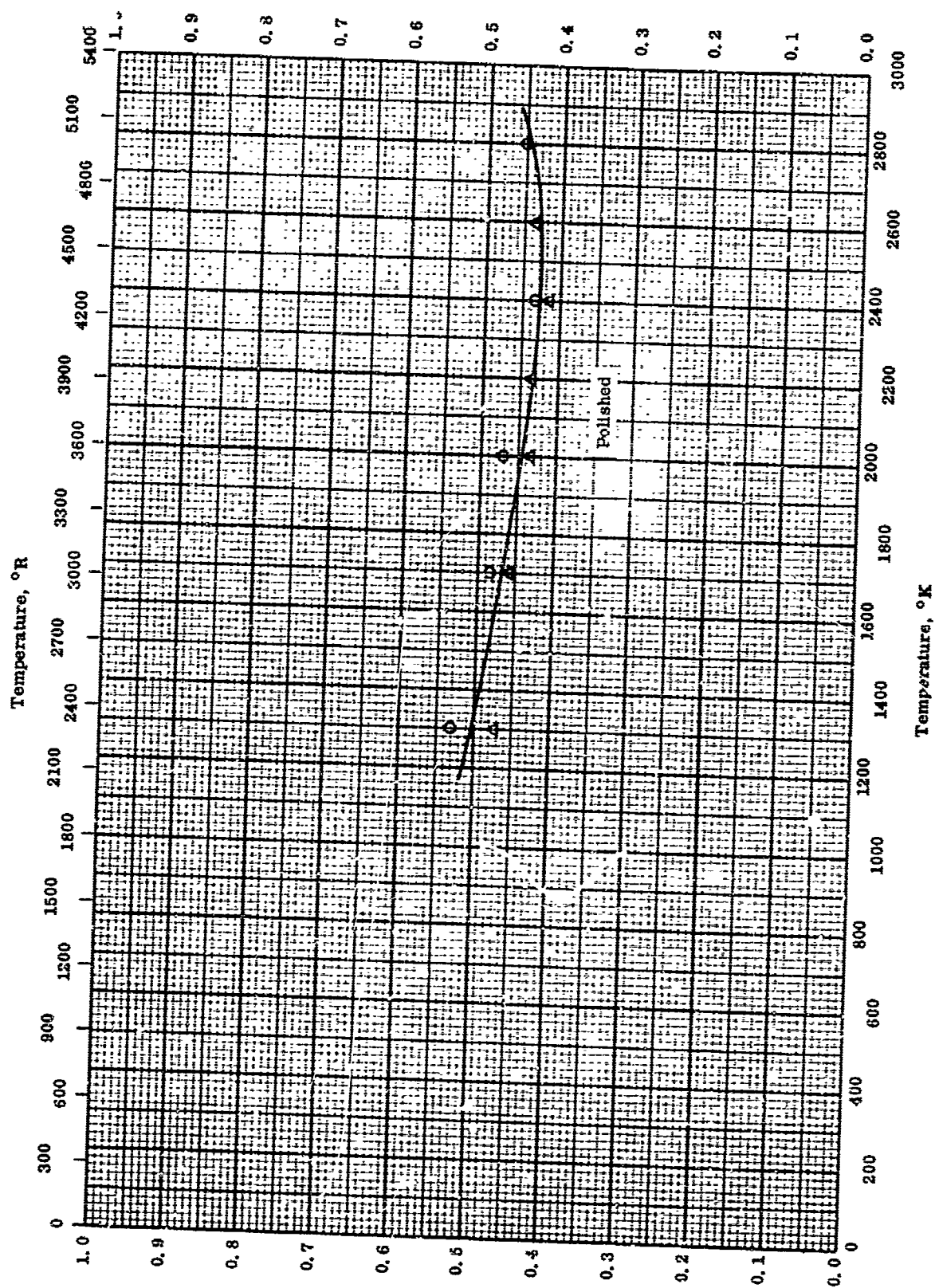
REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. Range, °K | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|---------------------|--------------------|-----------------|-----------------------|---|
| ○ | 62-20 | 0.65 | 2400-3200 | | 80 W and 20 Mo. | Polished with abrasive papers (No. 1, 00, 000 and 0000); measured in argon. |
| ▽ | 62-20 | 0.65 | 2400-3200 | | 70 W and 30 Mo. | Polished with abrasive papers (No. 1, 00, 000 and 0000); measured in argon. |

TPRC

Normal Spectral Emittance

573



NORMAL SPECTRAL EMITTANCE — TUNGSTEN + MOLYBDENUM

Normal Spectral Emittance

TPRC

NORMAL SPECTRAL EMITTANCE -- TUNGSTEN + MOLYBDENUM

REFERENCE INFORMATION

| Symbol | Ref. | Wavelength μ | Temp., K Range | Rept. Error % | Sample Specifications | Remarks |
|----------|------|---------------------|-------------------|------------------|---|---|
| O | 33-1 | 0.660 | 1300-2800 | ± 2 | 87.5 W and 12.5 Mo; tubular filament; manufactured by Cleveland Wire Works of the G. E. Co. | Formed from powdered metals; sintered; electrolytically polished in KOH solution, further polished by using 00, 000, and 0000 polishing papers (Manning Speed Grits). |
| Δ | 33-1 | 0.660 | 1300-2600 | ± 2 | 62.5 W and 37.5 Mo; tubular filament; manufactured by Cleveland Wire Works of the G. E. Co. | Same as above. |

TPRC

PROPERTIES OF TUNGSTEN + NIOBIUM

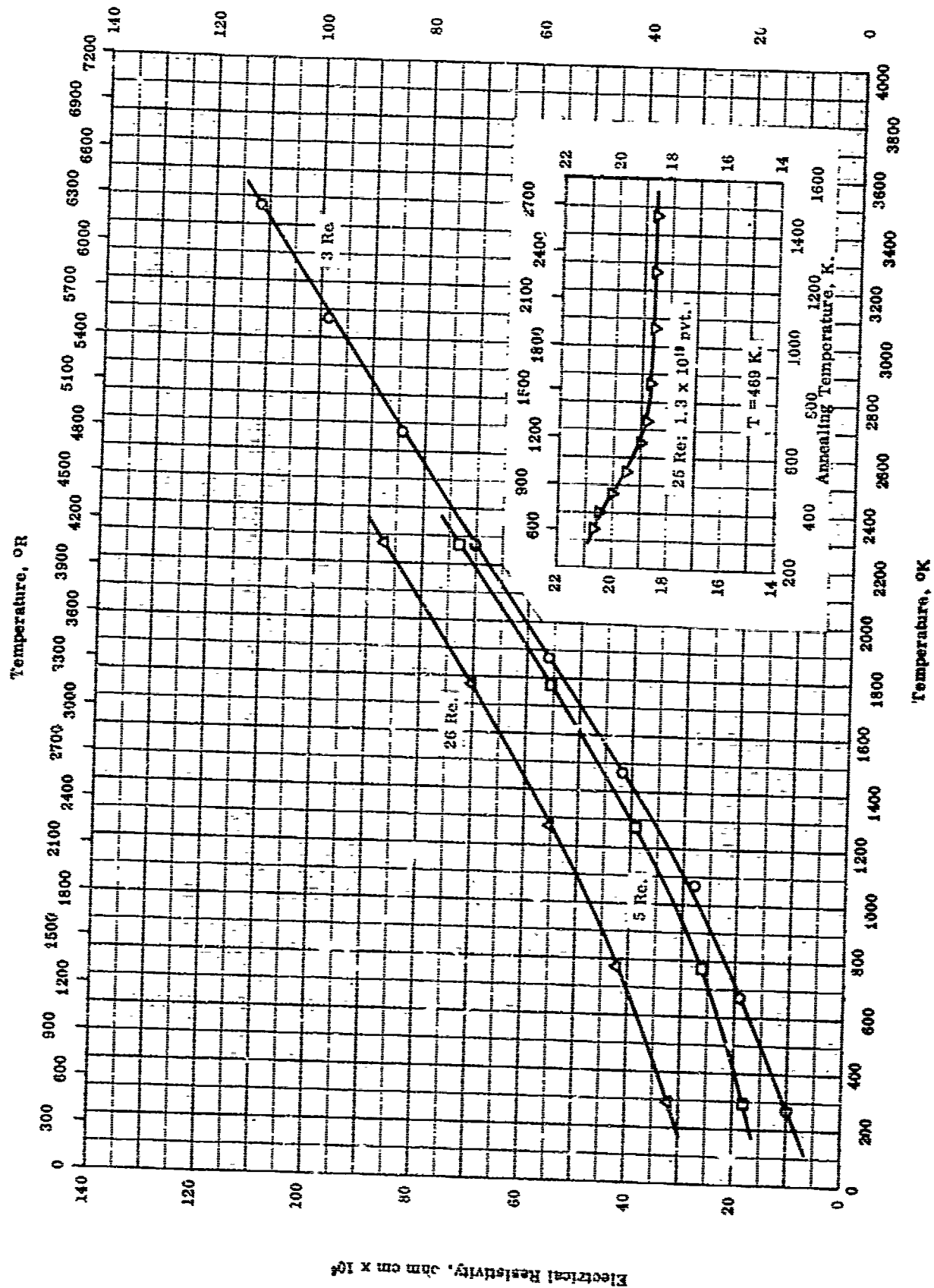
REPORTED VALUES

| Melting Point: | K | R |
|------------------|------|------|
| ○ 90 W and 20 Nb | 3488 | 6278 |
| □ 70 W and 30 Nb | 3293 | 5928 |
| △ 60 W and 40 Nb | 3223 | 5802 |
| ▽ 50 W and 50 Nb | 3148 | 5667 |

PROPERTIES OF TUNGSTEN + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| ○ | 58-21 | 3488 | | 80 W and 20 Nb; prepared from 99.95 W and 99.2 Nb powders. | Pressed at 121,000 psi, sintered 24 hrs at 600-650 C and 100 hrs at 1150 C, formed into rods, sintered 100 hrs at 1200 C and 45 hrs at 1500 C. |
| □ | 58-21 | 3293 | | 70 W and 30 Nb; same as above. | Same as above. |
| △ | 58-21 | 3223 | | 60 W and 40 Nb; same as above. | Same as above. |
| ▽ | 58-21 | 3148 | | 50 W and 50 Nb; same as above. | Same as above. |



ELECTRICAL RESISTIVITY -- TUNGSTEN + RHENIUM

ELECTRICAL RESISTIVITY -- TUNGSTEN + RHENIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 63-15 | 273-3473 | | 3 Re. | Wire. |
| □ | 63-15 | 208-2273 | | 5 Re. | Wire. |
| △ | 63-15 | 208-2273 | | 26 Re. | Wire or tubing. |
| ▽ | 64-5 | 433 | | 25 Re. | Irradiated to 1.3×10^{19} nvt; annealed in argon at indicated temperatures for 1 hr; data measured at 196 C. |

PROPERTIES OF URANIUM + CHROMIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------------|------------------------|------------------------|
| ○ 0.594 Cr | 18.697 | 1167.2 |
| □ 0.30 Cr | 18.697 | 1167.2 |
| ● 5.27 Cr | 17.44 | 1089 |
| ■ 5.42 Cr | 17.41 | 1097 |
| △ 5.60 Cr | 17.25 | 1077 |
| ◇ 5.60 Cr | 17.57 [*] | 1097 [*] |
| ▽ 5.92 Cr | 17.26 | 1078 |
| ▲ 5.0 Cr | 17.56 | 1096 |
| ▼ 5.0 Cr | 17.3 | 1080 |
| | | |
| Melting Point: | K | R |
| ◆ 5.6 Cr | 1132 ± 10 [*] | 2038 ± 20 [*] |

^{*}Most probable value for alloys of this composition.

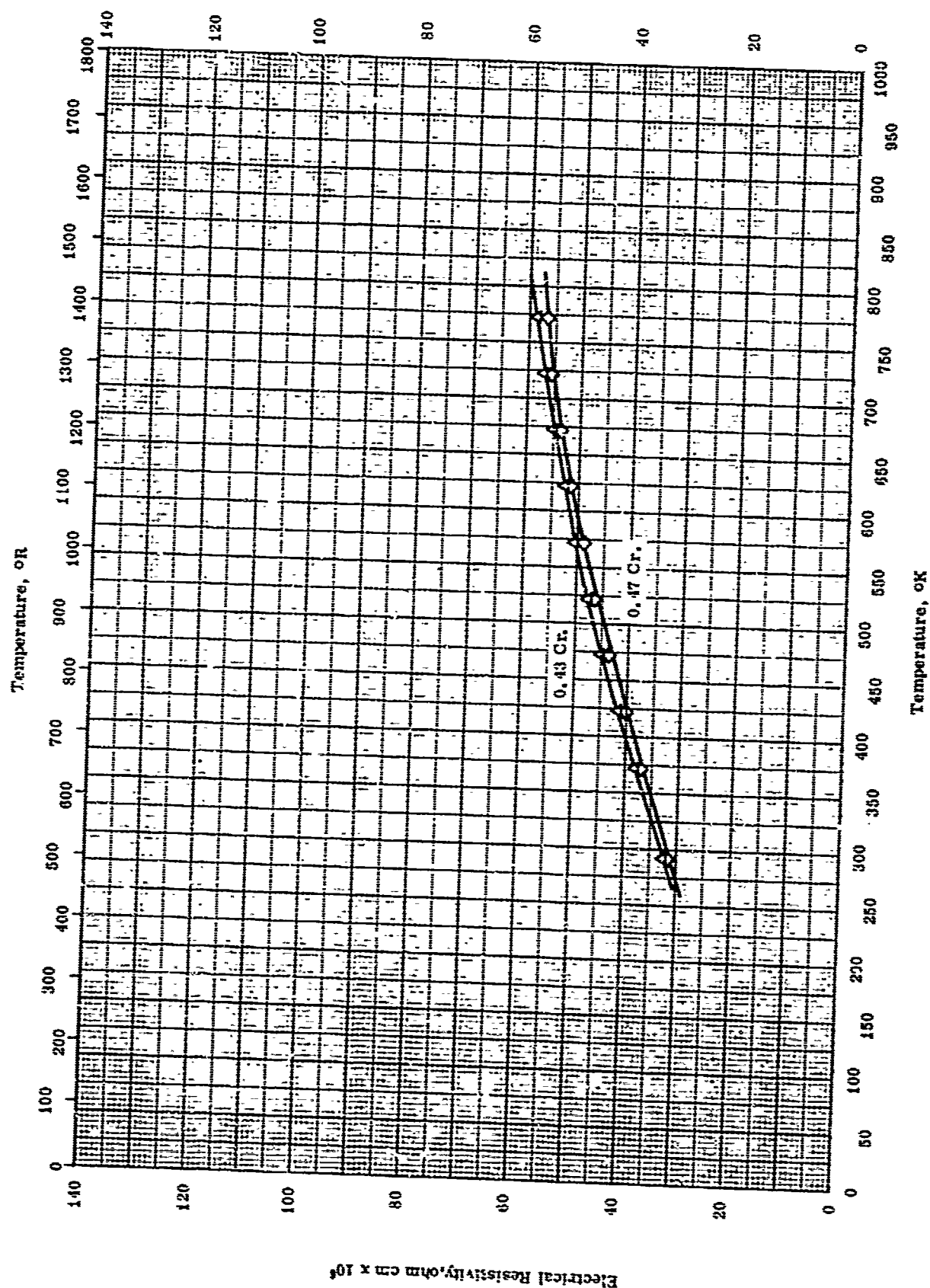
PROPERTIES OF URANIUM + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------------------------------|
| ○ | 51-14 | 298 | | 0.594 Cr; single crystal with β - phase. | Quenched from β - region. |
| □ | 50-9 | 298 | | 0.30 Cr; single crystal. | |
| ● | 53-11 | 298 | | 5.27 Cr. | |
| ■ | 53-11 | 298 | | 5.42 Cr. | |
| △ | 53-11 | 298 | | 5.60 Cr. | |
| ◆ | 53-11 | 1122-1142 | | 5.00 Cr. | Vacuum cast at 5-35 μ Hg. |
| ◇ | 53-11 | 298 | | 5.60 Cr. | |
| ▽ | 53-11 | 298 | | 5.92 Cr. | |
| ▲ | 53-11 | 298 | | 5 Cr. | |
| ▼ | 53-23 | 298 | | 5.1 Cr and 0.025 C. | |

Electrical Resistivity, ohm cm x 10⁶

581



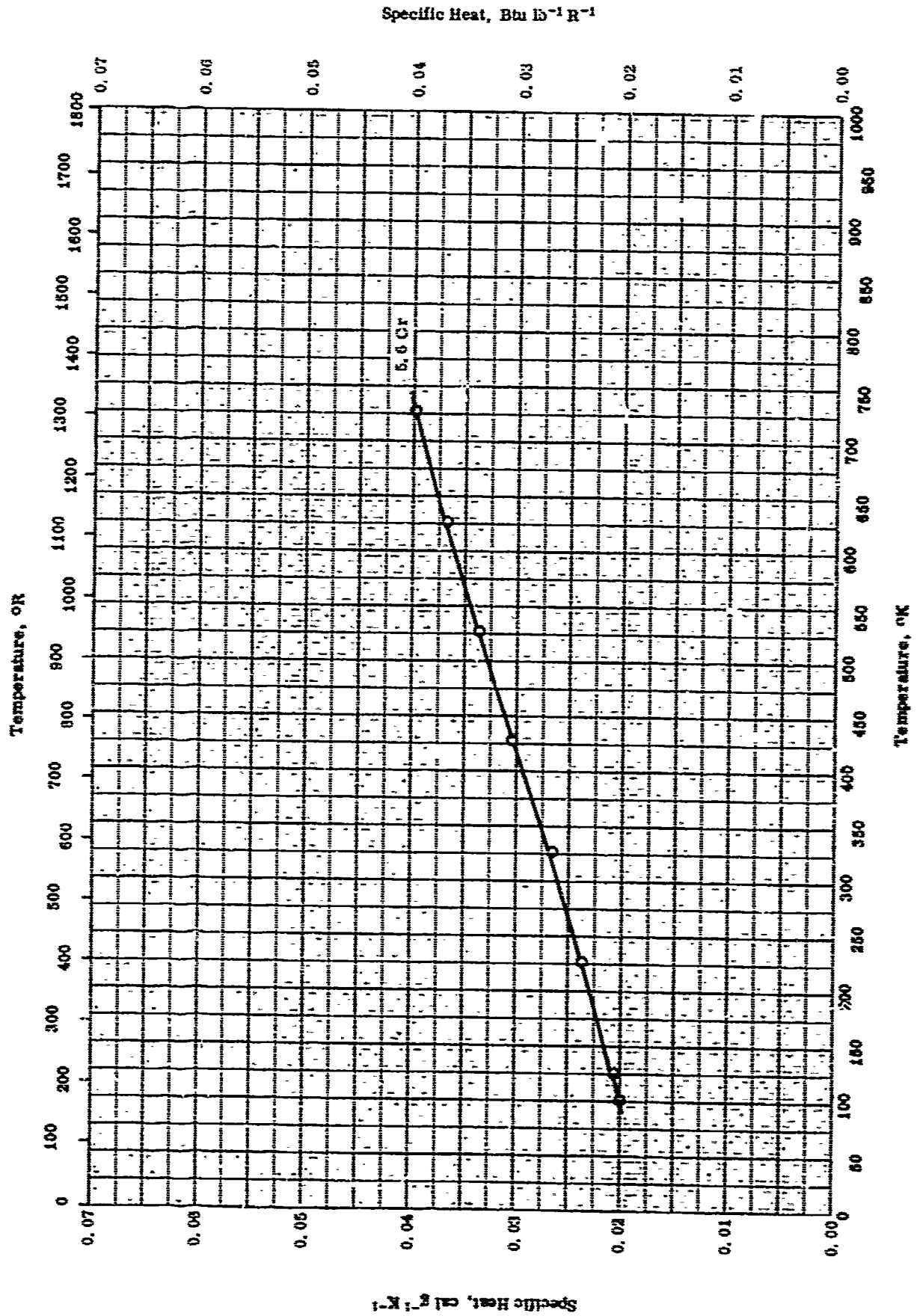
ELECTRICAL RESISTIVITY -- URANIUM + CHROMIUM

TPRC

ELECTRICAL RESISTIVITY -- URANIUM + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| △ | 55-21 | 293-773 | | 0.43 Cr and 0.01 > C. | Heated 15 min. at 715 ± 10 C; quenched to 575 ± 10 C; held 25 min, then water quenched, reheated 15 min. at 715 ± 10 C, quenched to 500 ± 10 C, held 90 min; and water quenched. |
| ◇ | 55-21 | 293-773 | | 0.47 Cr and 0.08 C. | Same as above. |



SPECIFIC HEAT -- URANIUM + CHROMIUM

SPECIFIC HEAT -- URANIUM + CHROMIUM

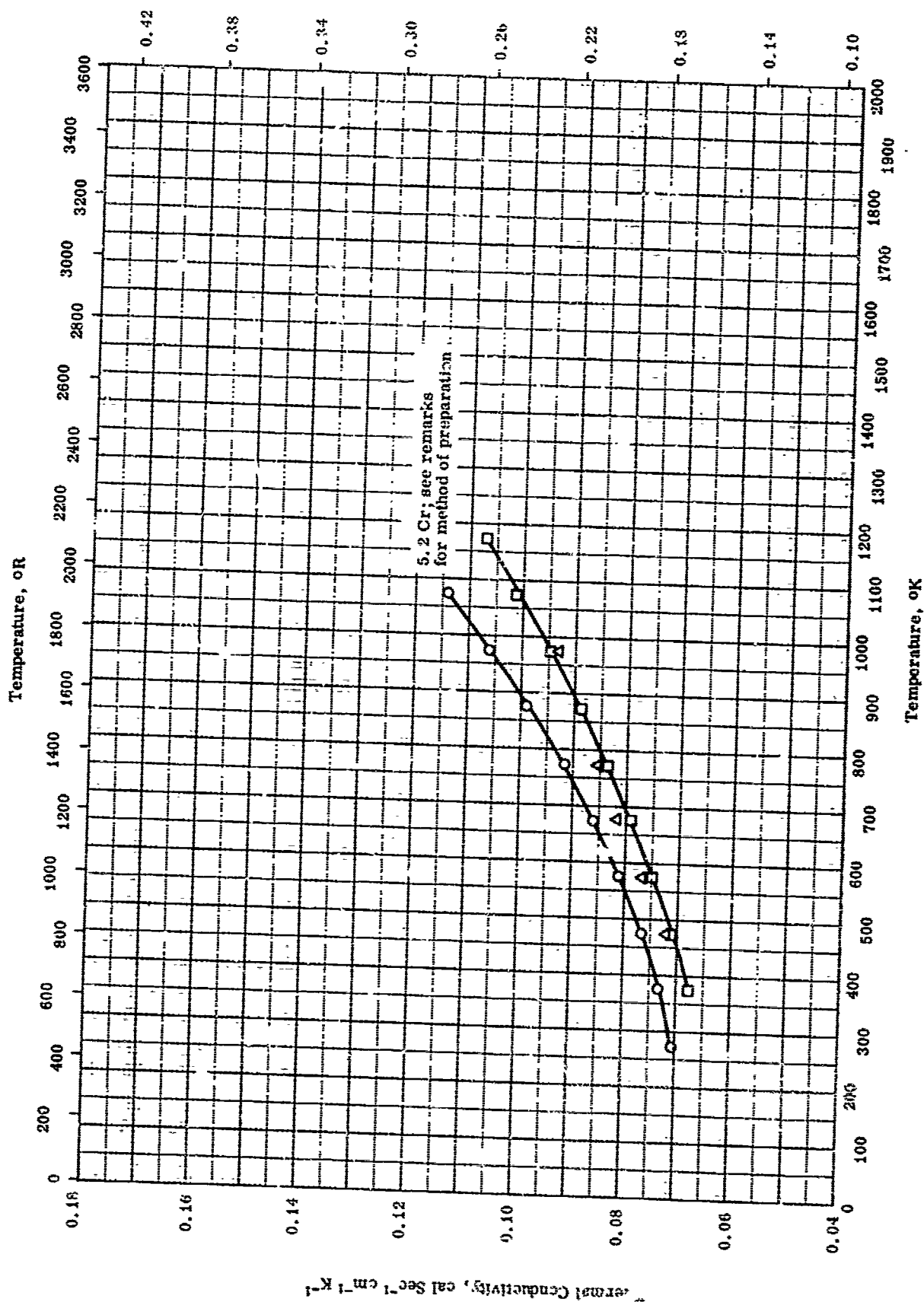
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|------------------------------|---|
| O | 53-11 | 273-898 | | U-Cr eutectic alloy; 5.6 Cr. | Mean specific heat from 0 C to given temperature. |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

585



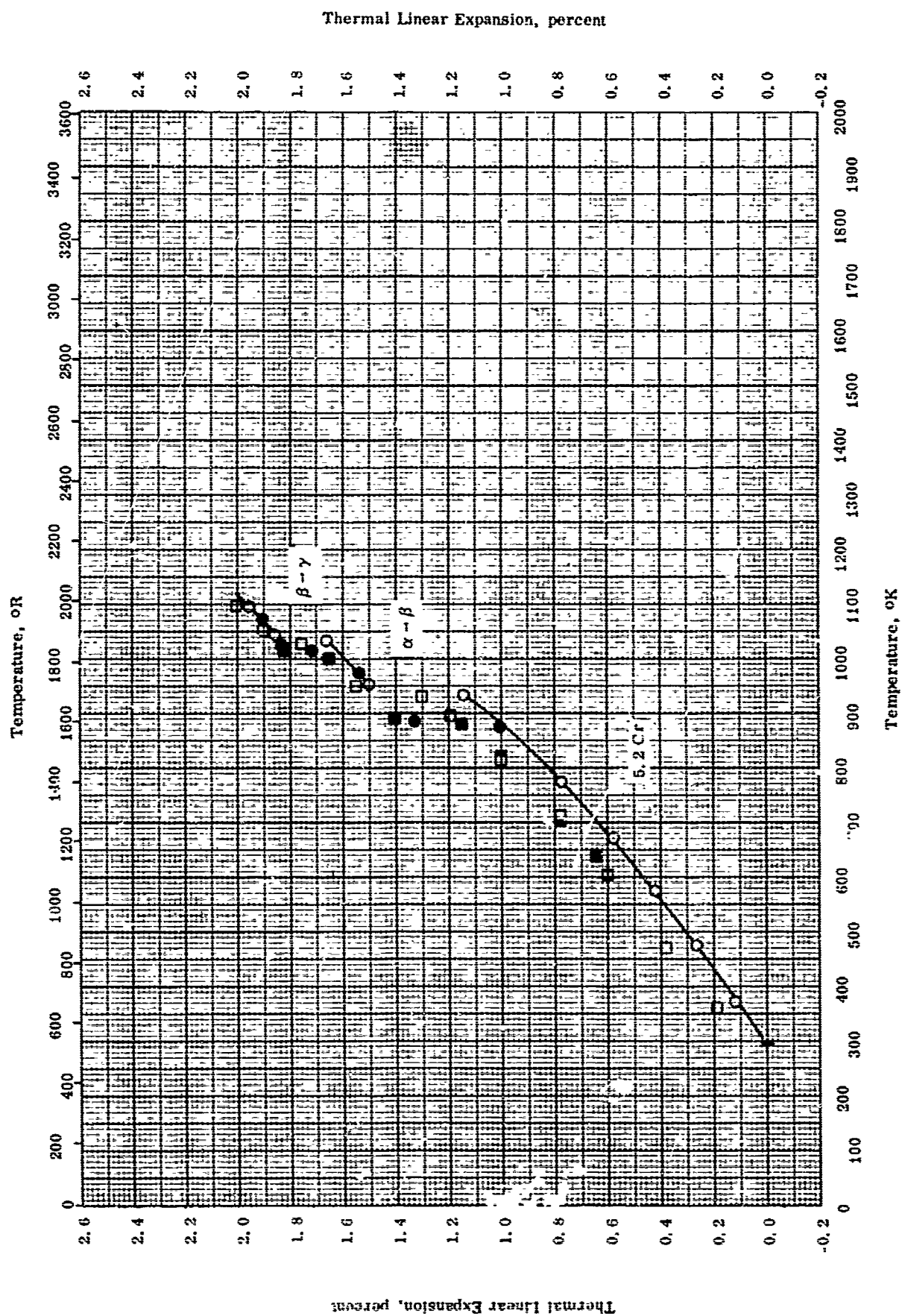
THERMAL CONDUCTIVITY -- URANIUM + CHROMIUM

TPRC

THERMAL CONDUCTIVITY -- URANIUM + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|------------------------------|---|
| ○ | 54-4 | 273-1073 | | 5.2 Cr; Nominal composition. | Biscuit uranium cast in cold graphite; avg. of 2 samples within 3%. |
| □ | 54-4 | 373-1173 | | Same as above. | Biscuit uranium cast in warm graphite; avg. of 2 samples within 4%. |
| △ | 54-4 | 373-1173 | | Same as above. | Biscuit uranium cast in copper. |



THERMAL LINEAR EXPANSION -- URANIUM + CHROMIUM

TPRC

THERMAL LINEAR EXPANSION --- URANIUM + CHROMIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------------------|---|
| ○ | 54-4 | 293-1093 | | Eutectic Alloy; nominally 3.2 Cr. | 12 samples; induction melted and formed in various ways; effect of method of forming is insignificant; heating. |
| ● | 54-4 | 293-1093 | | Same as above. | Cooling; below 1572 K, results same as heating curve. |
| □ | 53-23 | 348-1025 | | 5.1 Cr and 0.0250 C. | Vacuum cast 5 - 35 μ lig; heating; measured in argon. |
| ■ | 53-23 | 348-1025 | | Same as above. | Cooling. |

TPRC

PROPERTIES OF URANIUM + IRON

REPORTED VALUES

| Density | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| O 10.7 Fe | 15.8 | 986 |

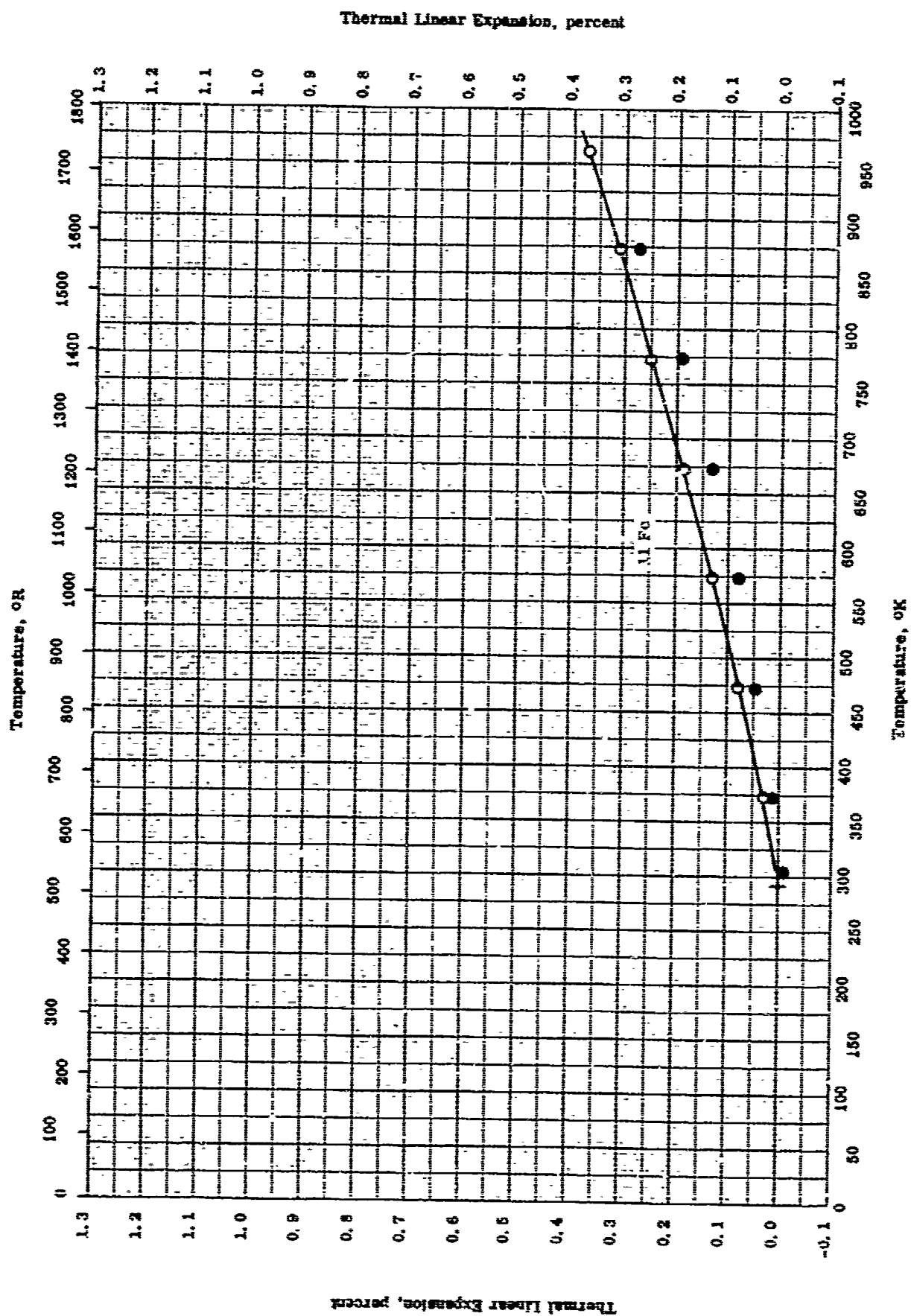
TPRC

PROPERTIES OF URANIUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| O | 53-23 | 298 | | 10.7 Fe and 0.0335 C. | Cast at 5-35 μ Hg vacuum; density from weight and volume by water displacements. |

TPRC

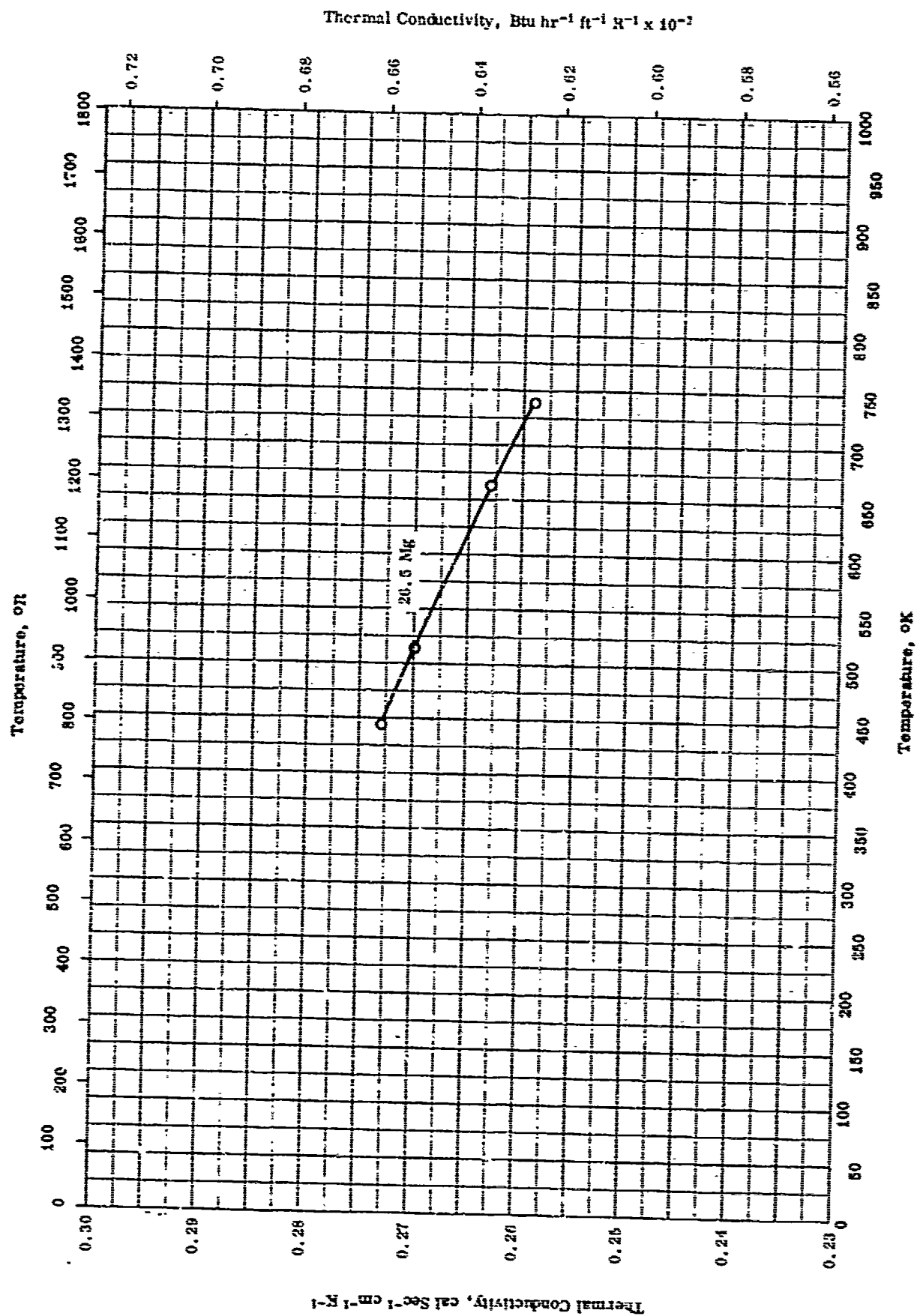


THERMAL LINEAR EXPANSION -- URANIUM + IRON

THERMAL LINEAR EXPANSION -- URANIUM + IRON

REFERENCE INFORMATION

| Sym bol | Ref. | T, mp. Range °K | Rep. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|-----------------|-----------------------|--|
| ○ | 53-23 | 300-963 | | 10.7 Fo and 0.0335 C. | Cast at $P = 35 \mu$ Hg vacuum: heating. |
| ● | 53-23 | 300-963 | | Same as above. | Cooling. |

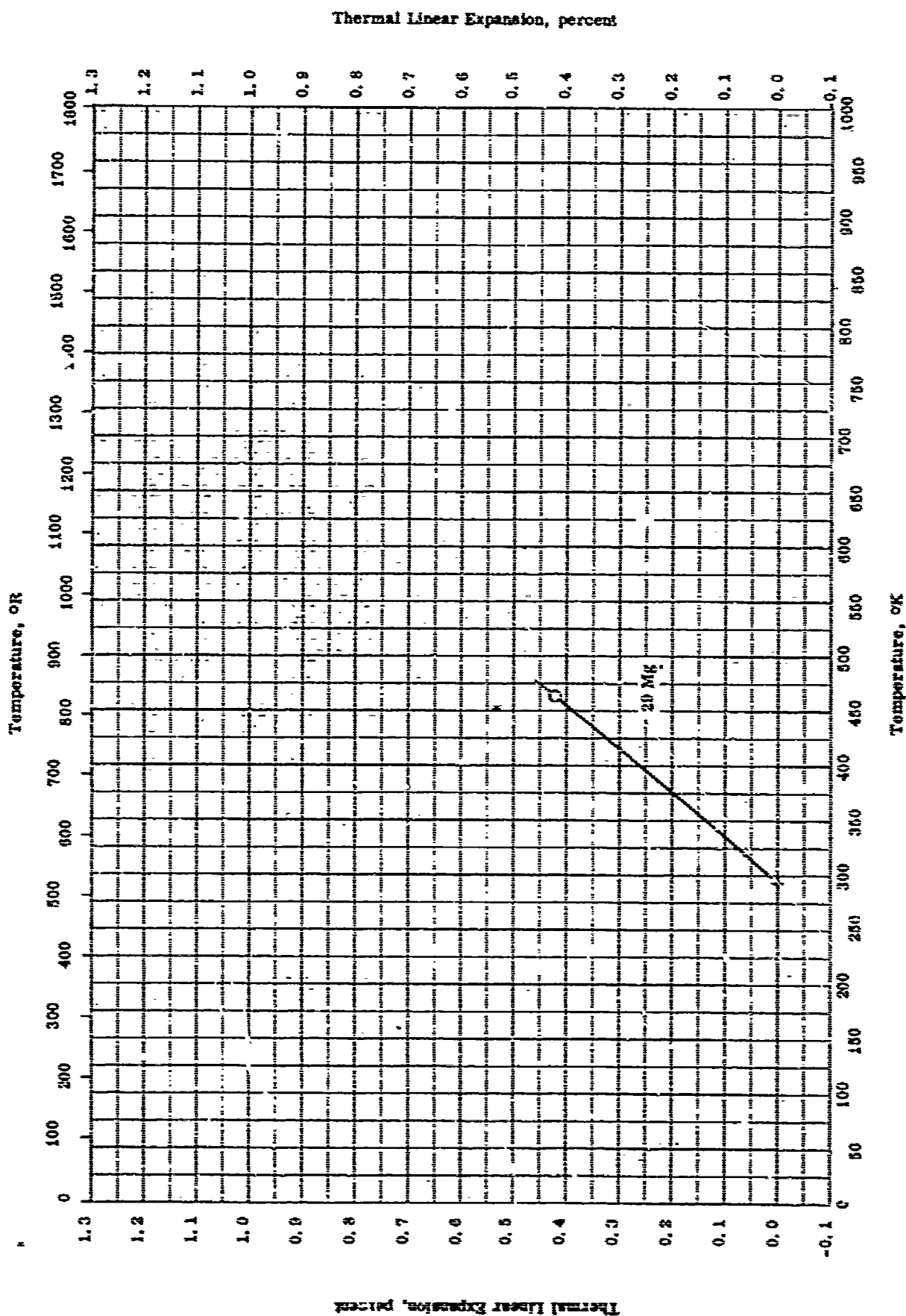


THERMAL CONDUCTIVITY -- URANIUM + MAGNESIUM

THERMAL CONDUCTIVITY -- URANIUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|-----------|
| O | 67-8 | 440-738 | | 71.5 U and 26.5 Mg. | Extruded. |



THERMAL LINEAR EXPANSION -- URANIUM + MAGNESIUM

THERMAL LINEAR EXPANSION -- URANIUM + MAGNESIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| O | 52-26 | 293-463 | | 71 U and 29 Mg. | Powders mixed, cold compacted, and hot extruded; measured parallel to direction of extrusion in argon. |

TPRC

PROPERTIES OF URANIUM + MOLYBDENUM

REPORTED VALUES

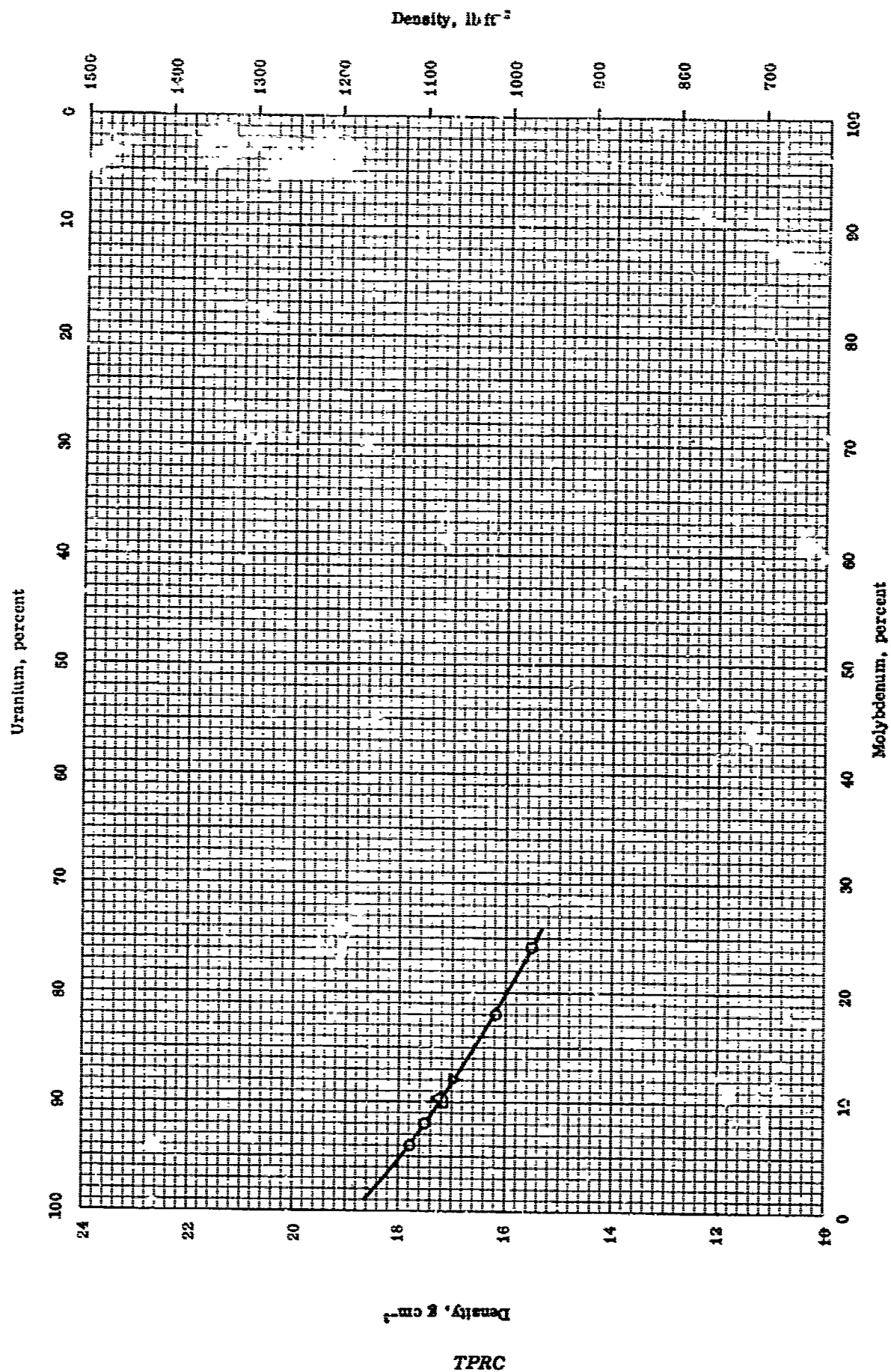
| | | |
|----------------|------------|------|
| Density: | See figure | |
| Melting Point: | K | R |
| O 12 Mo | 1423 | 2561 |

PROPERTIES OF URANIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|----------------------|
| C | 55-8 | 1423 | ± 4 | 12 Mo. | Quenched from 900 C. |

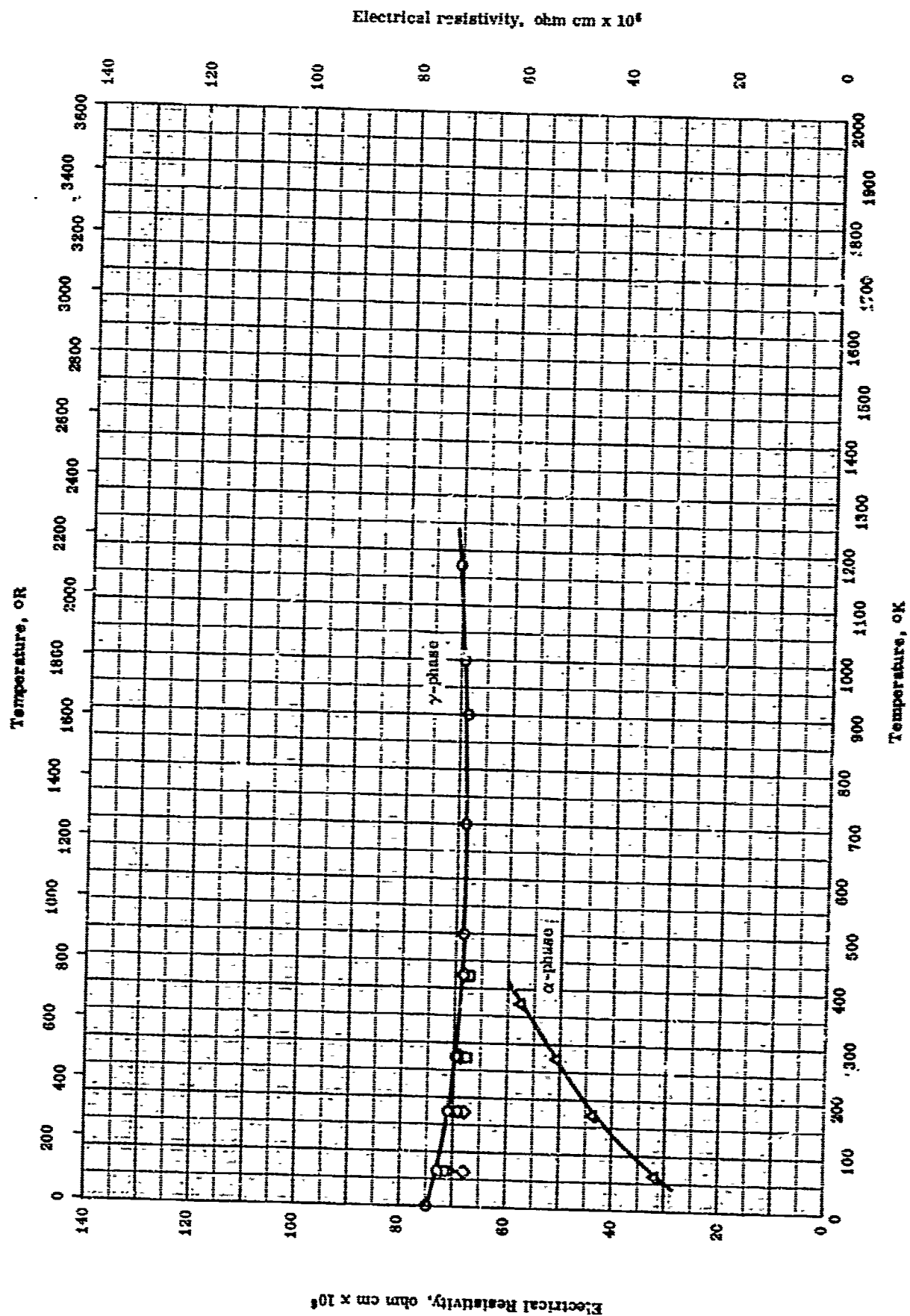
TPRC



DENSITY -- URANIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|--------|-------------------|------------------|--|--|
| ○ | 55-8 | 298 | ± 4 | 0-24 Mo. | Quenched from 230 °C; density by weight in air and in CCl ₄ . |
| □ | 57-45 | 298 | | 90 U and 10 Mo; metastable γ - phase. | |
| △ | " - 46 | 298 | | 90 U and 10 Mo; fully transformed stable phase (γ + β) | |
| ▽ | 55-8 | 298 | ± 4 | 12 Mo. | Quenched from 900 °C; density by weight in air and in CCl ₄ . |

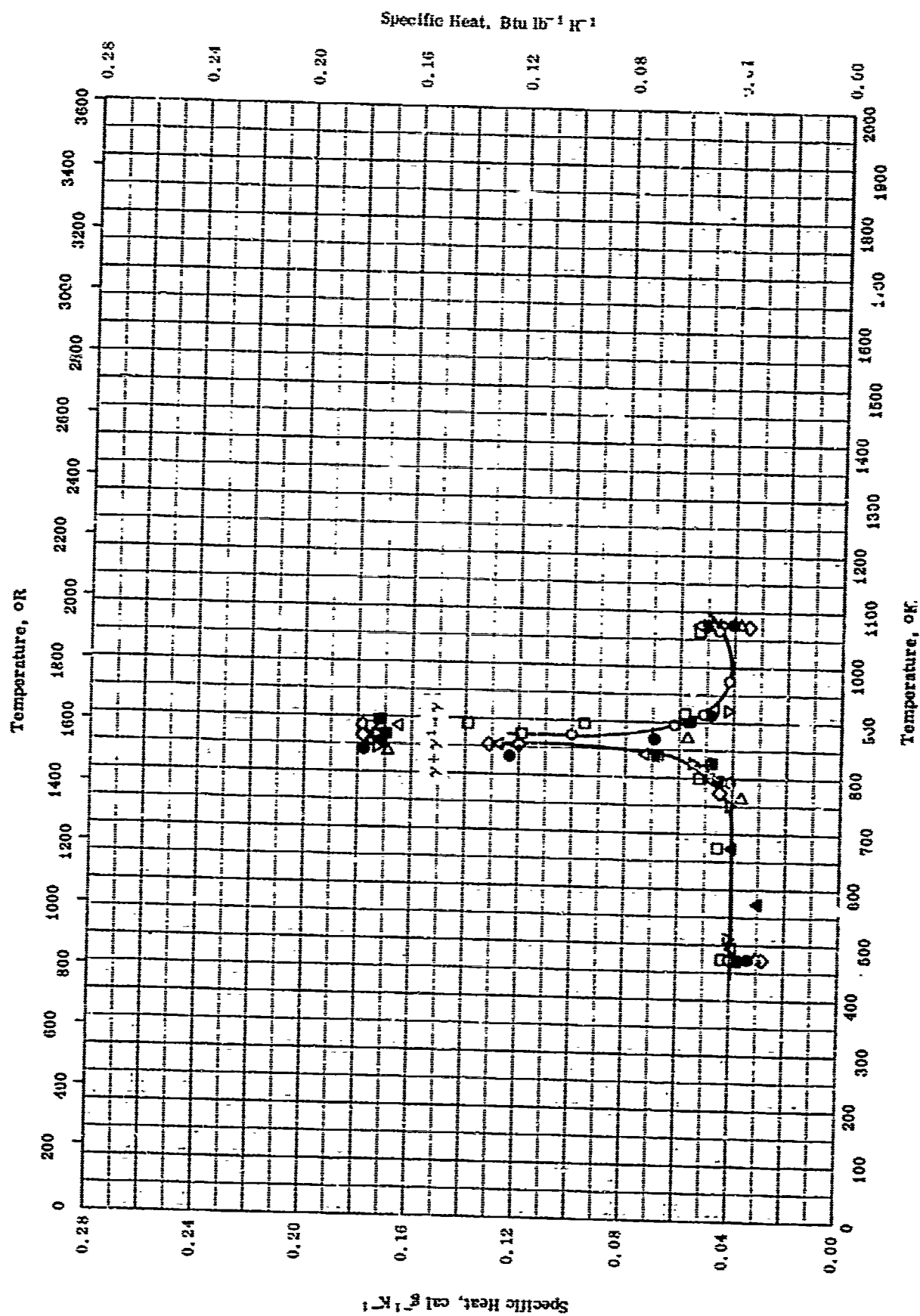


ELECTRICAL RESISTIVITY --- URANIUM + MOLYBDENUM

ELECTRICAL RESISTIVITY -- URANIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|-----------------------|--|
| ○ | 56-35 also 57-16 | 0-1172 | | 9 Mo. | γ-quenched; relative data above 760 K, used $\epsilon_{400} = 0.05 \times 10^{-6}$ ohm cm. |
| □ | 56-35 also 57-16 | 73-373 | | Same as above. | γ-quenched; 0.07% burnup. |
| △ | 56-35 also 57-16 | 73-373 | | Same as above. | γ-quenched, then α-transformed by 13 days at 525 C. |
| ◇ | 56-35 also 57-16 | 73-373 | | Same as above. | γ-quenched, then α-transformed by 13 days at 525 C; 0.088% burnup. |
| ▽ | 56-35 also 57-16 | 73-373 | | Same as above. | γ-quenched, then α-transformed by 13 days at 525 C; 0.092% burnup. |



SPECIFIC HEAT -- URANIUM + MOLYBDENUM

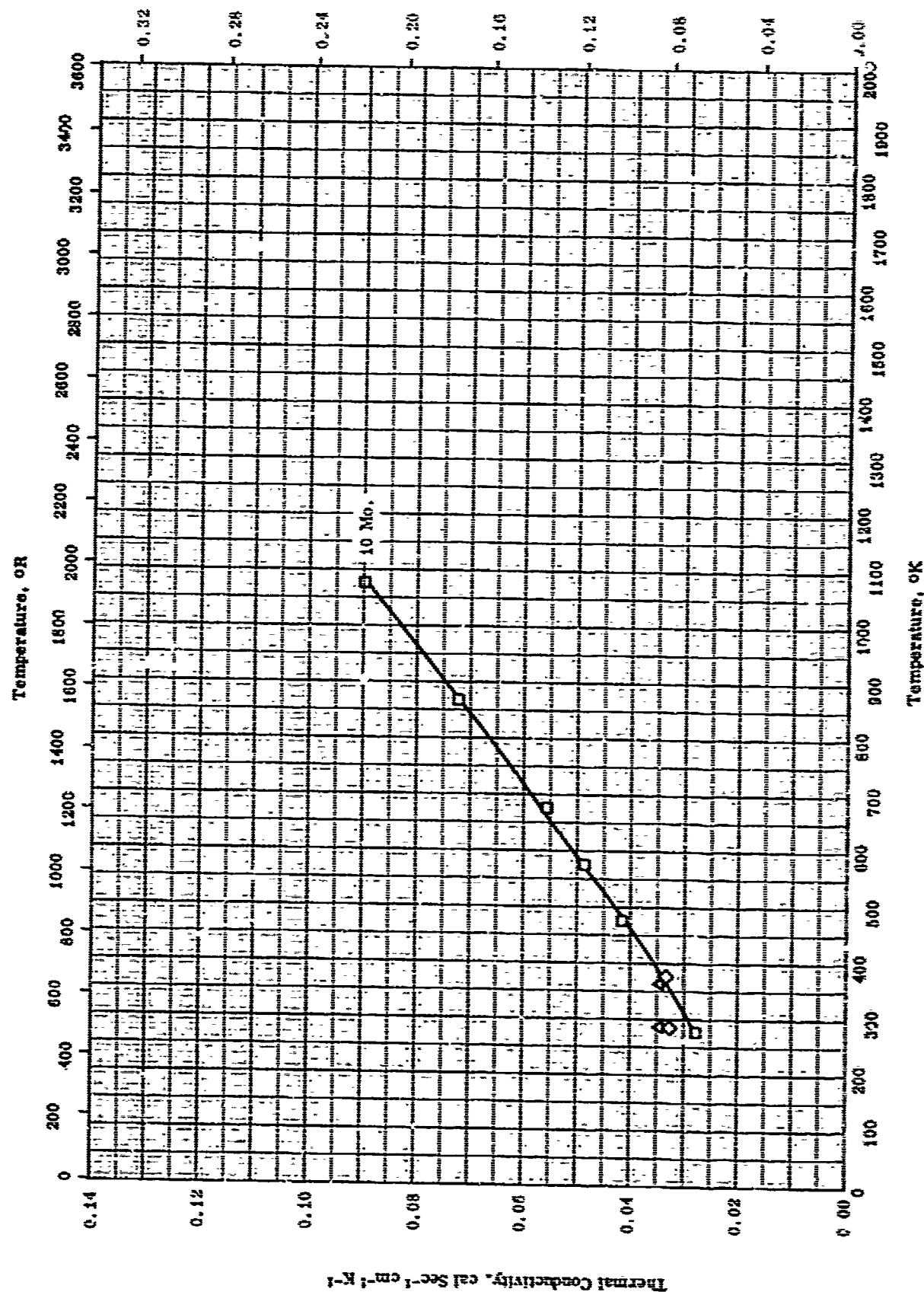
SPECIFIC HEAT -- URANIUM + MOLOYBDENUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 57-10 | 473-1063 | | 15.2 Mo. | Annealed 7 days at 590 C, held 44 days at 500 C. |
| □ | 58-15 | 473-1073 | | 21.5 Mo. | Heated 24 hrs at 900 C to γ phase, water quenched, ordered 96 days at 500 C. |
| △ | 58-15 | 473-1073 | | 7 Mo. | Heated 24 hrs at 900 C to γ phase, water quenched, ordered 7 days at 475 C. |
| ◇ | 58-15 | 473-1073 | | 8 Mo. | Heated 24 hrs at 900 C to γ phase, water quenched, ordered 159 days at 400 C. |
| ▽ | 58-15 | 473-1073 | | 10.5 Mo, 0.028 C. | Same as above. |
| ● | 58-15 | 473-1073 | | 11.3 Mo, 0.046 C, 0.0035 N ₂ . | Same as above. |
| △ | 50-15 | 473-1073 | | 12 Mo, 0.008 C, 0.0071 N ₂ . | Heated 24 hrs, at 900 C to γ phase, water quenched, ordered 243 days at 400 C. |
| ■ | 56-15 | 473-1073 | | 15.2 Mo, 0.028 C, 0.007 N ₂ . | Heated 24 hrs at 900 C to γ phase, water quenched, ordered 96 days at 570 C. |
| ▲ | 55-6 | 673-873 | | 12 Mo, α uranium + ϵ phase. | |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-3}$

605



THERMAL CONDUCTIVITY -- URANIUM + MOLYBDENUM

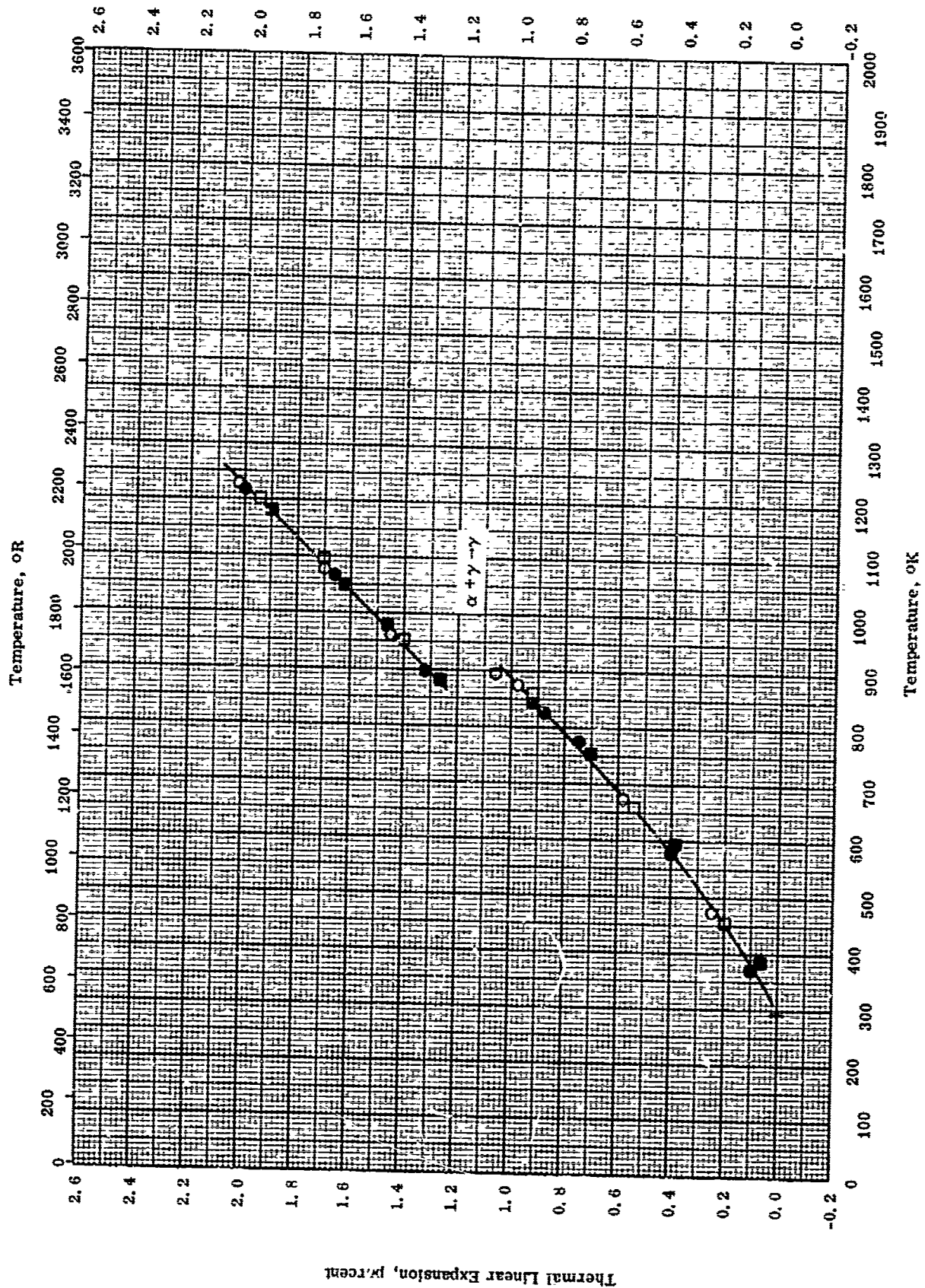
TPRC

THERMAL CONDUCTIVITY -- URANIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|-------------------------|
| □ | 58-13 | 273-1073 | | 90 U and 10 Mo. | |
| △ | 55-8 | 283-373 | | 92 U and 8 Mo. | α U + ϵ |
| ◇ | 55-8 | 283-373 | | 88 U and 12 Mo. | α U + ϵ |

TPRC



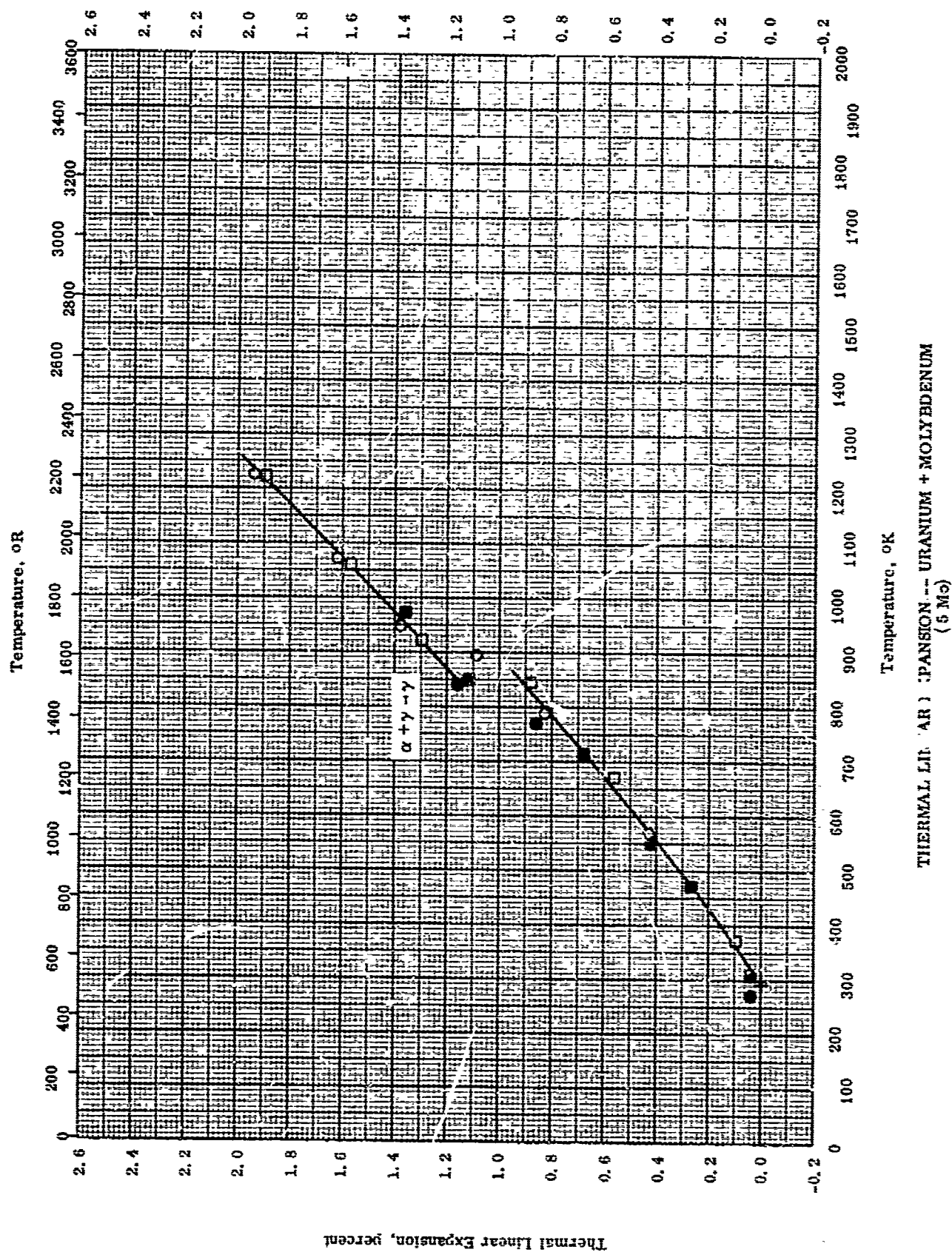
Thermal Linear Expansion --- URANIUM + MOLYBDENUM
(3.34 Mo)

THERMAL LINEAR EXPANSION -- URANIUM + MOLYBDENUM
(3.34 Mo)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 58-45 | 295-1222 | | 3.34 Mo. | Heated 1 hr at 800 C and air cooled; specimen protected in glass envelope; heating. |
| ● | 56-45 | 373-1222 | | Same as above. | Cooling. |
| □ | 56-45 | 295-1222 | | Same as above. | Heated 1 hr at 800 C and water quenched; heating |
| ■ | 56-45 | 389-1222 | | Same as above. | Cooling. |

TPRC



Thermal Life (AR) : Pansion --- URANIUM + MOLYBDENUM
(5 Mo)

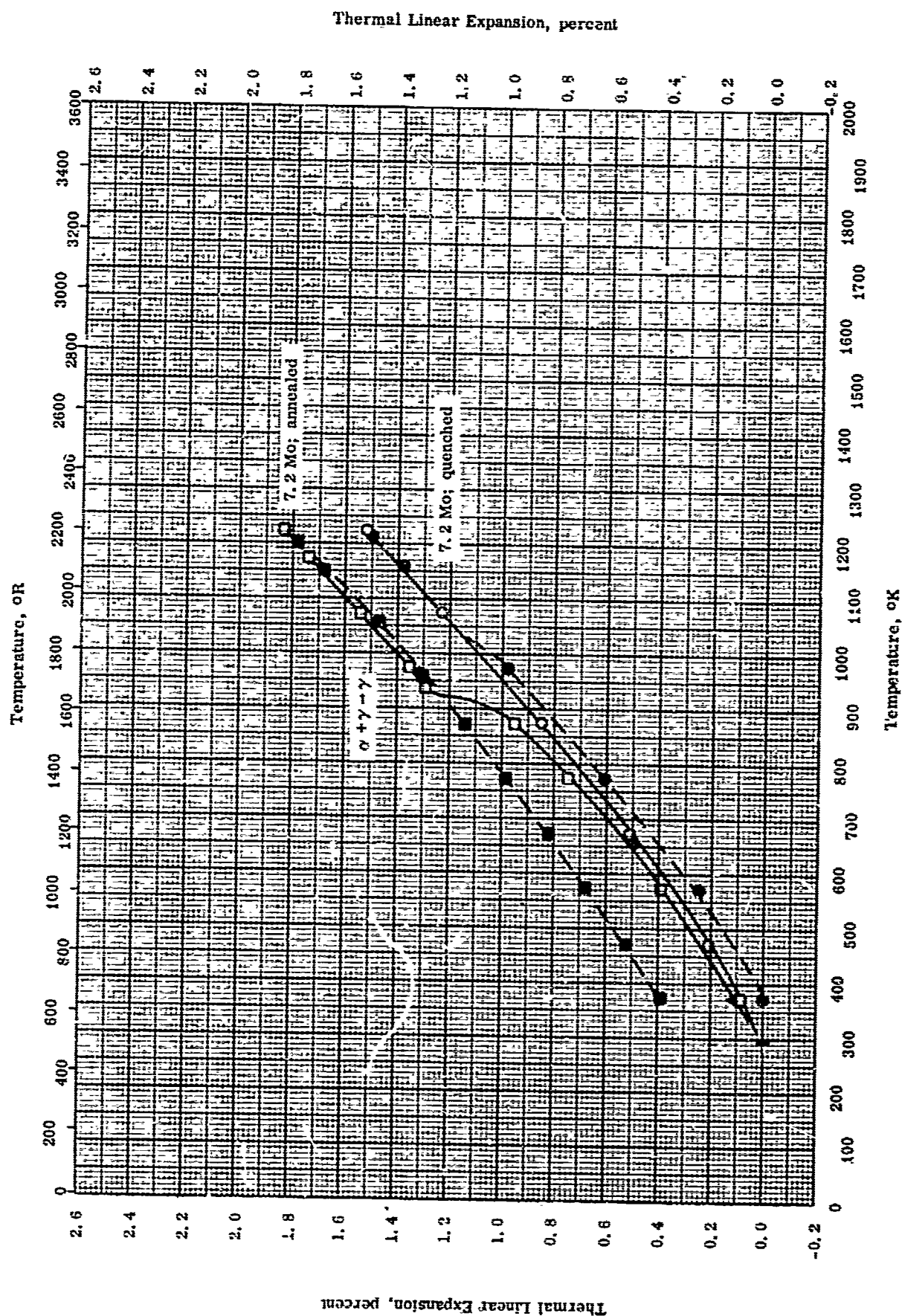
TPRC

THERMAL LINEAR EXPANSION -- URANIUM - MOLYBDENUM
(5 Mo)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 56-45 | 295-1223 | | 4.99 Mo. | Held 1 hr at 800 C and water quenched; heating. |
| ● | 56-45 | 277-1223 | | Same as above. | Cooling. |
| □ | 56-45 | 295-1223 | | Same as above. | Held 1 hr at 800 C, furnace cooled to 500 C, held 24 hrs, and furnace cooled; heating. |
| ■ | 56-45 | 308-1223 | | Same as above. | Cooling. |

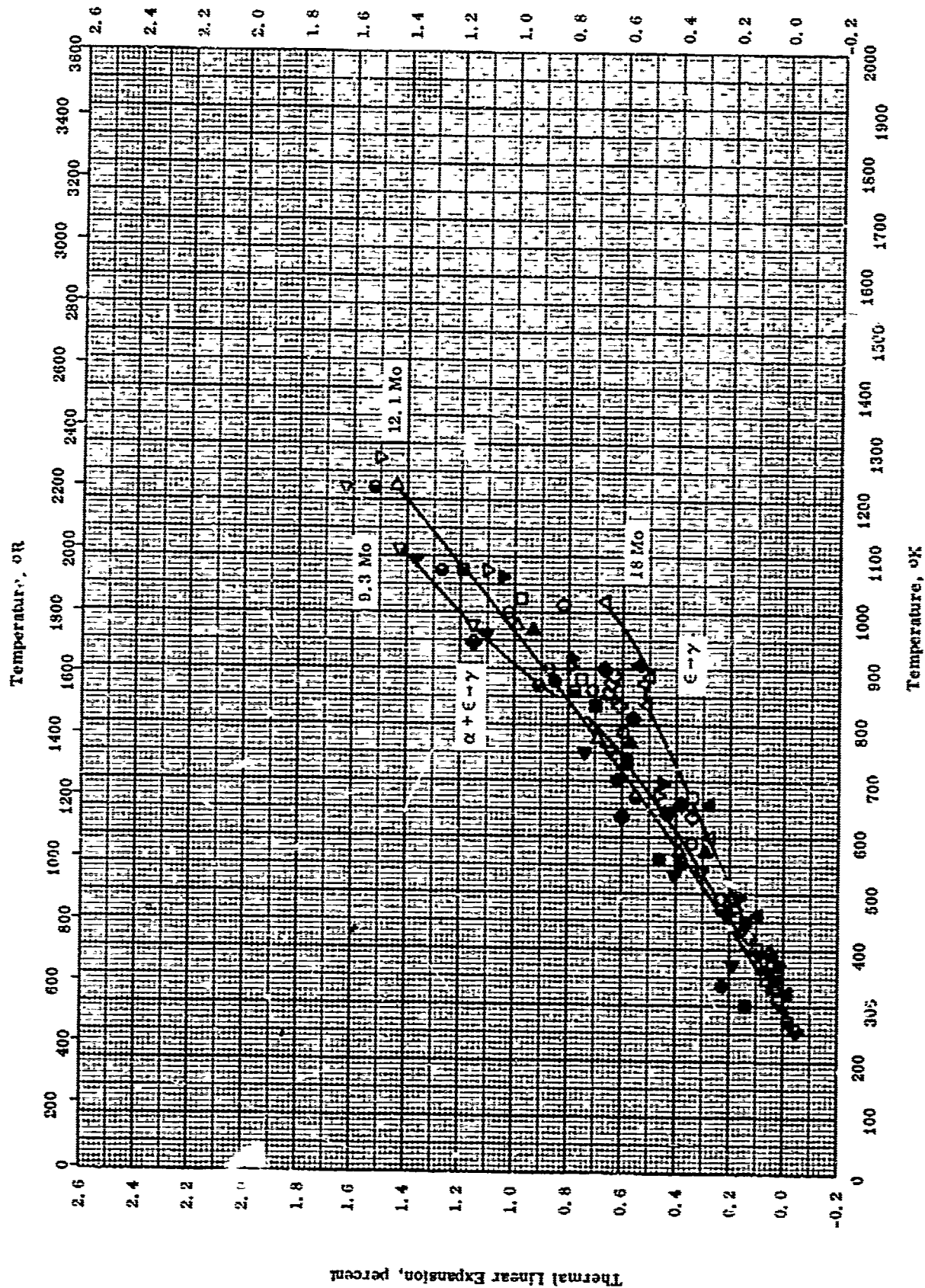
TPRC



THERMAL LINEAR EXPANSION -- URANIUM + MOLYBDENUM
(7 < Mo ≤ 8)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 56-45 | 295-1223 | | 7.18 Mo. | Held 1 hr at 800 C and water quenched; heating. |
| ● | 56-45 | 373-1223 | | Same as above. | Cooling. |
| □ | 56-45 | 295-1223 | | Same as above. | Held 1 hr at 800 C, furnace cooled to 500 C, held 100 hrs at 500 C, and furnace cooled; heating. |
| ■ | 56-45 | 373-1223 | | Same as above. | Cooling. |
| △ | 55-8 | 372-673 | | 8 Mo. | |



THERMAL LINEAR EXPANSION -- URANIUM + MOLYBDENUM
(9 ≤ Mo ≤ 18)

THERMAL LINEAR EXPANSION --- URANIUM + MOLYBDENUM
($9 \leq Mo \leq 18$)

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Temp. Error % | Sample Specifications | Remarks |
|----------------------------|----------------------------------|-------------------|------------------|-----------------------|-------------------------------------|
| ○ | 55-8, 56-35, also 57-16 | 333-998 | | 9 Mo. | Annealed 16 days at 550 C, heating. |
| ● | 55-8, 56-35, also 57-16 | 333-998 | | Same as above. | Cooling. |
| □ | 55-8, 56-35, also 57-16 | 293-1028 | | 12 Mo. | Same as above; heating. |
| ■ | 55-8, 56-35, also 57-16 | 300-1028 | | Same as above. | Cooling. |
| ◇ | 55-8, 56-35, also 57-16 | 313-1013 | | 15 Mo. | Same as above; heating. |
| (continued onto next page) | | | | | |

Thermal Linear Expansion -- URANIUM + MOLYBDENUM (Continued)
(9 ≤ Mo ≤ 18)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|----------------------------------|-------------------|------------------|--|--|
| ◆ | 55-8, 56-36, also 57-16 | 302-1013 | | Same as above. | Cooling. |
| △ | 55-8, 56-35, also 57-16 | 313-1013 | | 18 Mo. | Same as above. |
| ▲ | 55-8, 56-35, also 57-16 | 326-1013 | | Same as above. | Cooling. |
| ▽ | 56-45 | 293-1273 | | 12.1 Mo. | Held 1 hr at 800 °C and water quenched; heating; tested in vac. |
| ▼ | 56-45 | 377-1273 | | Same as above. | Cooling. |
| △ | 56-45 | 293-1273 | | Same as above. | Same as above except furnace cooled at 500 °C and held 2 weeks at 500 °C instead of quenched; heat- ing. |
| ▲ | 56-45 | 400-1273 | | Same as above. | Cooling. |
| ▽ | 56-45 | 293-1222 | | 9.36 Mo. | Same as above; heating. |
| ▼ | 56-45 | 371-1223 | | Same as above. (continued onto next page) | Cooling. |

THERMAL LINEAR EXPANSION -- URANIUM + MOLYBDENUM (Continued)
($9 \leq Mo \leq 18$)

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rep. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-----------------------|--|
| ① | 56-46 | 293-1223 | | Same as above. | Hold 1 hr at 800 C and water quenched; heating, tested in vacuum. |
| ② | 50-46 | 305-1223 | | Same as above. | Cooling. |
| ③ | 57-45 | 293-948 | | 10 Mo. | Extruded, heat treated at 900 C, and water quenched. |

PROPERTIES OF URANIUM + NIOBIUM

REPORTED VALUES

| Melting Point: | K | R |
|----------------|------|------|
| O 10 Nb | 1573 | 2531 |

PROPERTIES OF URANIUM + NIOBIUM

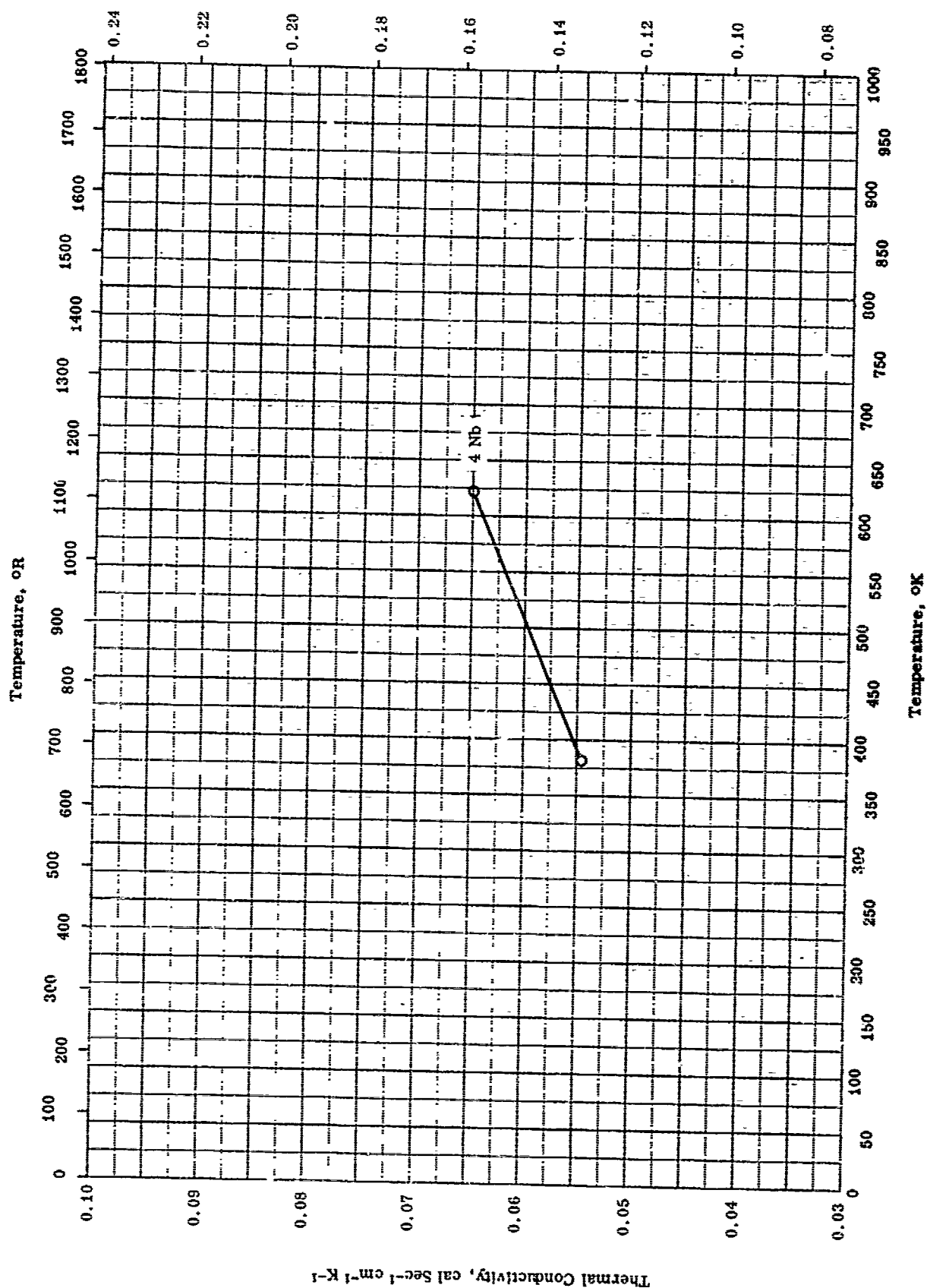
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---------|
| O | 55-8 | 1573 | | 10 Nb. | |

TPRC

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

619



THERMAL CONDUCTIVITY -- URANIUM + NIOBIUM

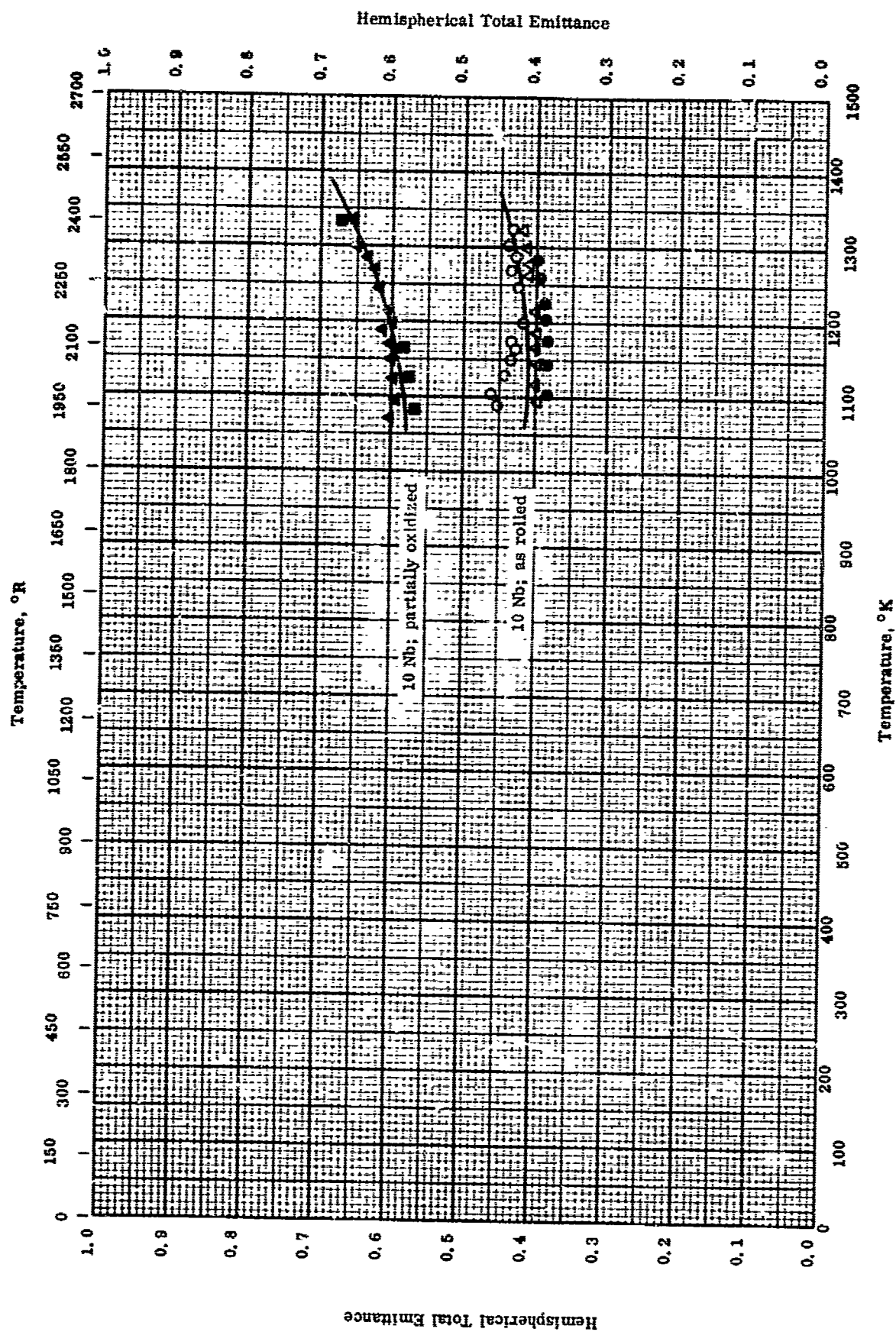
TPRC

THERMAL CONDUCTIVITY -- URANIUM + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---------|
| O | 45-1 | 386-623 | | 4 Nb | |

TPRC

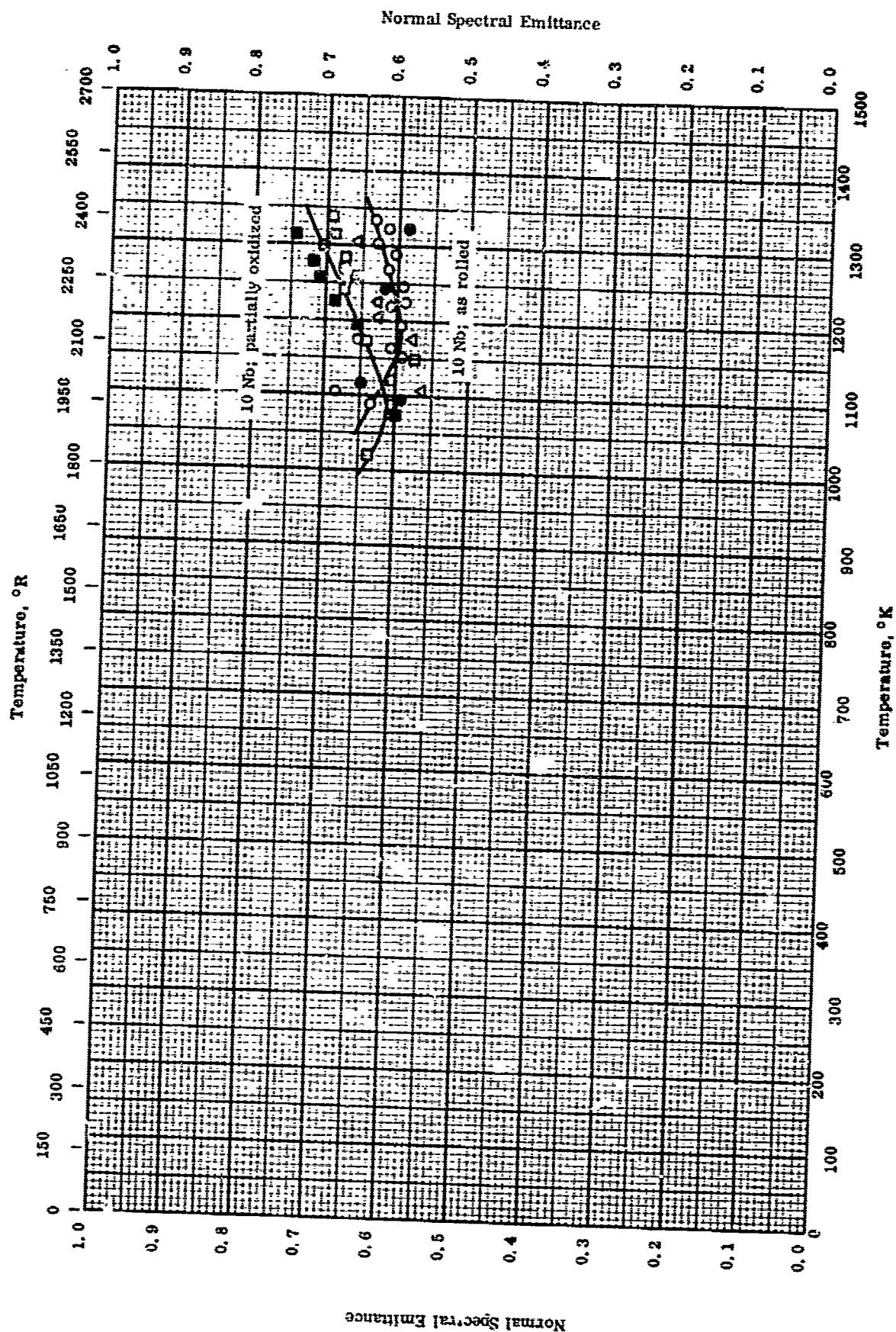


HEMISPHERICAL TOTAL EMITTANCE -- URANIUM + NIOBIUM

HEMISPHERICAL TOTAL EMITTANCE -- URANIUM + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 57-49 | 1090-1323 | | 90 U, 10 Nb. | As rolled; measured in vacuum; first heating. |
| △ | 57-49 | 1095-1323 | | Same as above. | Same as above; first cooling. |
| ● | 57-49 | 1105-1283 | | Same as above. | Same as above; second cooling. |
| ▲ | 57-49 | 1070-1335 | | Same as above. | Same as above except 15 charges (2.5 cm ³ at atmospheric pressure per charge) of oxygen added to vacuum chamber (chamber at 2×10^{-5} mmHg and specimen at approximately 1173 °K); heating. |
| ■ | 57-49 | 1082-1334 | | Same as above. | Same as above; cooling. |



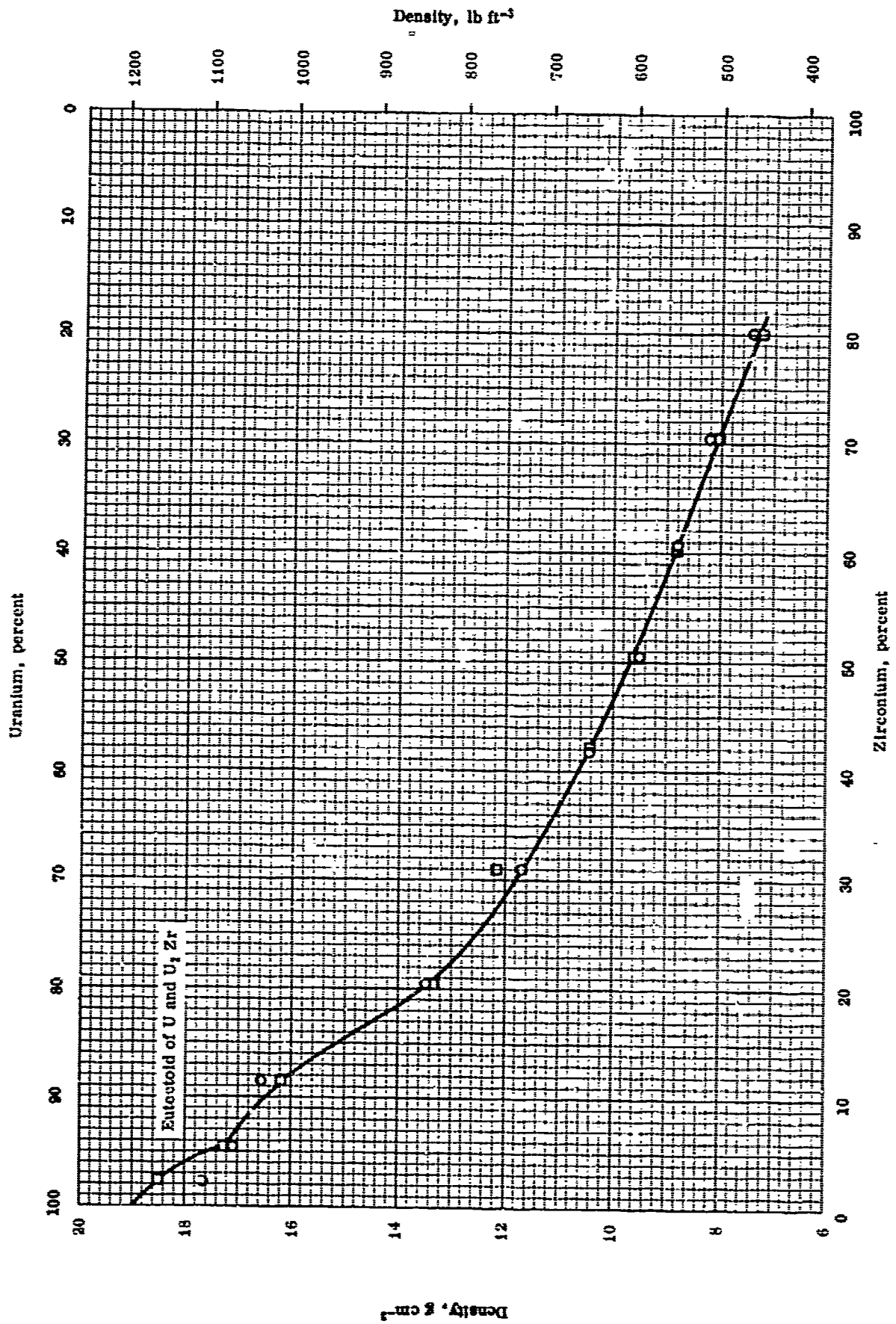
NORMAL SPECTRAL EMITTANCE — URANIUM + NIOBIUM

TPRC

NORMAL SPECTRAL EMITTANCE -- URANIUM + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. Range, °K | Rept. Error% | Sample Specifications | Remarks |
|------------|-------|---------------------|--------------------|-----------------|-----------------------|--|
| ○ | 57-49 | 0.65 | 1090-1336 | | 90 U, 10 Nb. | As rolled; measured in vacuum; first heating. |
| ● | 57-49 | 0.65 | 1095-1323 | | 90 U, 10 Nb. | Same as above; first cooling. |
| △ | 57-49 | 0.65 | 1106-1306 | | 90 U, 10 Nb. | Same as above, second cooling. |
| □ | 57-49 | 0.65 | 1020-1338 | | 90 U, 10 Nb. | Same as above except 15 charges (2.5 cm. ³ at atmospheric pressure per charge) of oxygen added to vacuum chamber (chamber at 2×10^{-5} mm Hg and specimen at approximately 1173 K); heating. |
| ■ | 57-49 | 0.65 | 1081-1315 | | 90 U, 10 Nb. | Same as above; cooling. |



DENSITY -- URANIUM + ZIRCONIUM

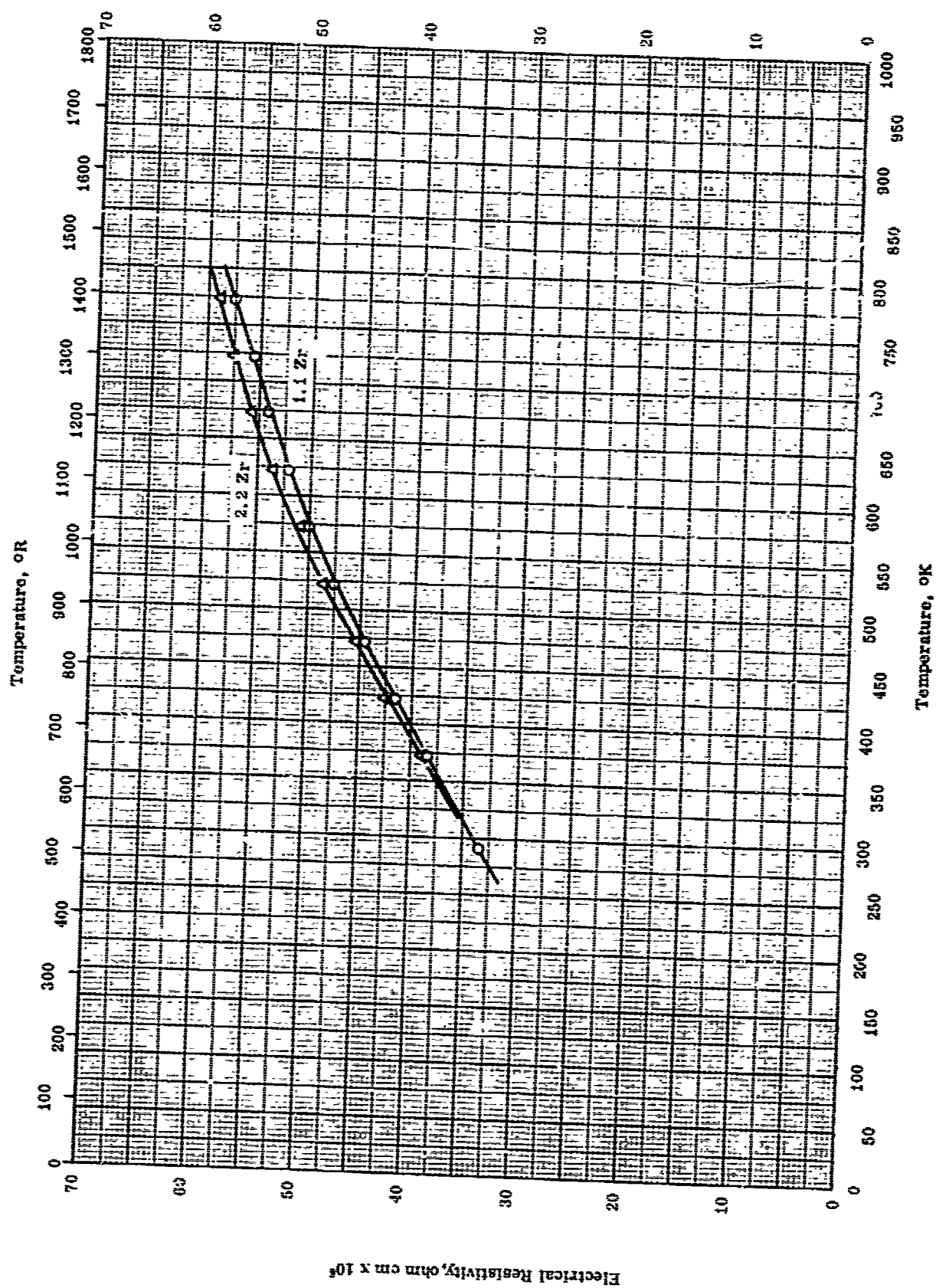
DENSITY --URANIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 53-22 | 298 | | 2-80 Zr. | Heat-treated 1 hr at 800 C and water quenched. |
| □ | 53-22 | 298 | | 2-80 Zr. | Heat-treated 24 hrs at 575 C and furnace cooled. |

Electrical Resistivity, ohm cm x 10⁶

627



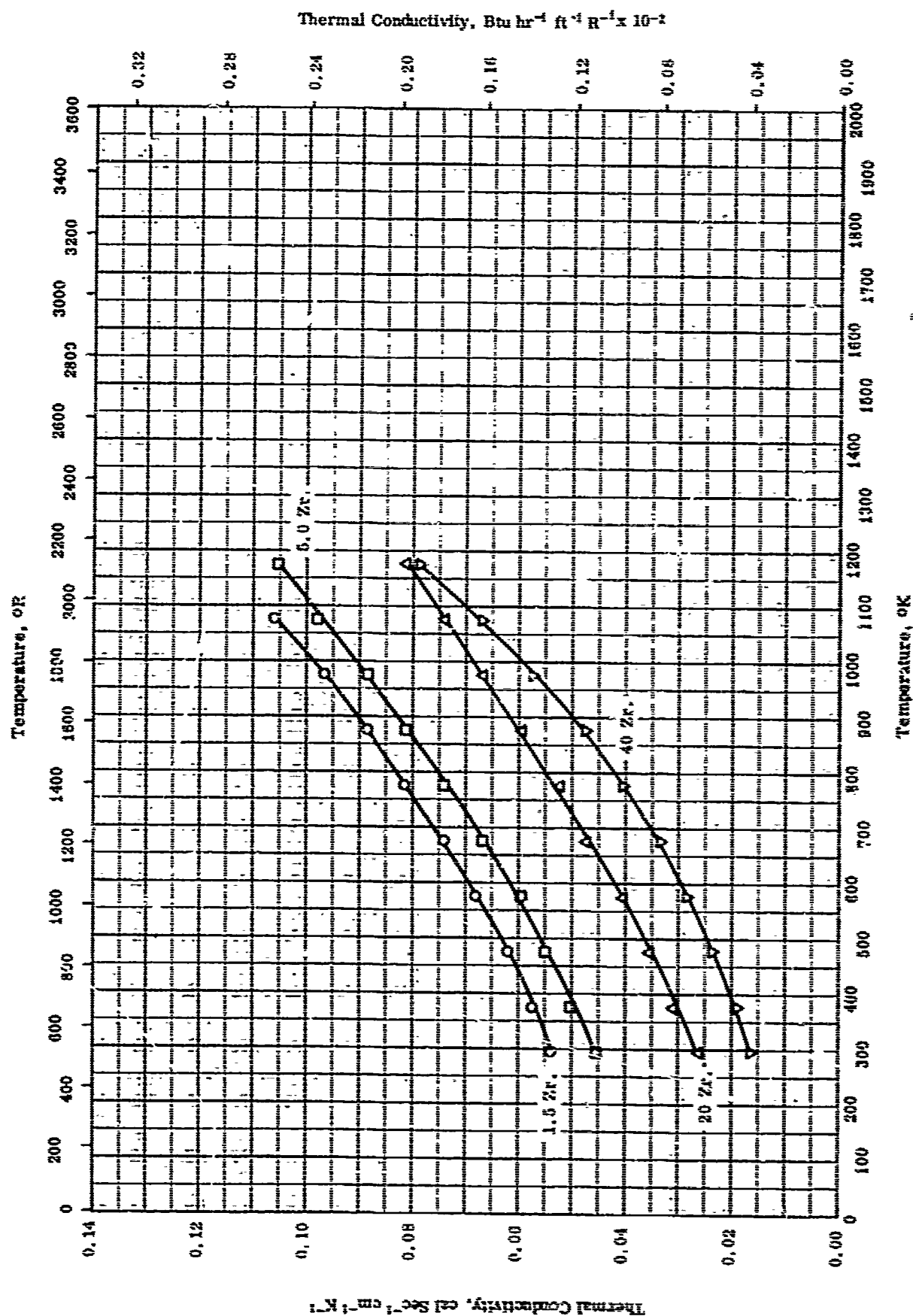
ELECTRICAL RESISTIVITY -- URANIUM + ZIRCONIUM

TPRC

ELECTRICAL RESISTIVITY -- URANIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------------|---|
| O | 55-21 | 293-1073 | | 1. 13 Zr and ≤ 0.01 C. | Heated 1 hr at 725 C in vacuum and water quenched. |
| A | 55-21 | 293-1073 | | 2. 22 Zr and ≤ 0.01 C. | Heated 1 hr. at 800 C in vacuum, 1 hr. at 500 C, and air cooled. |



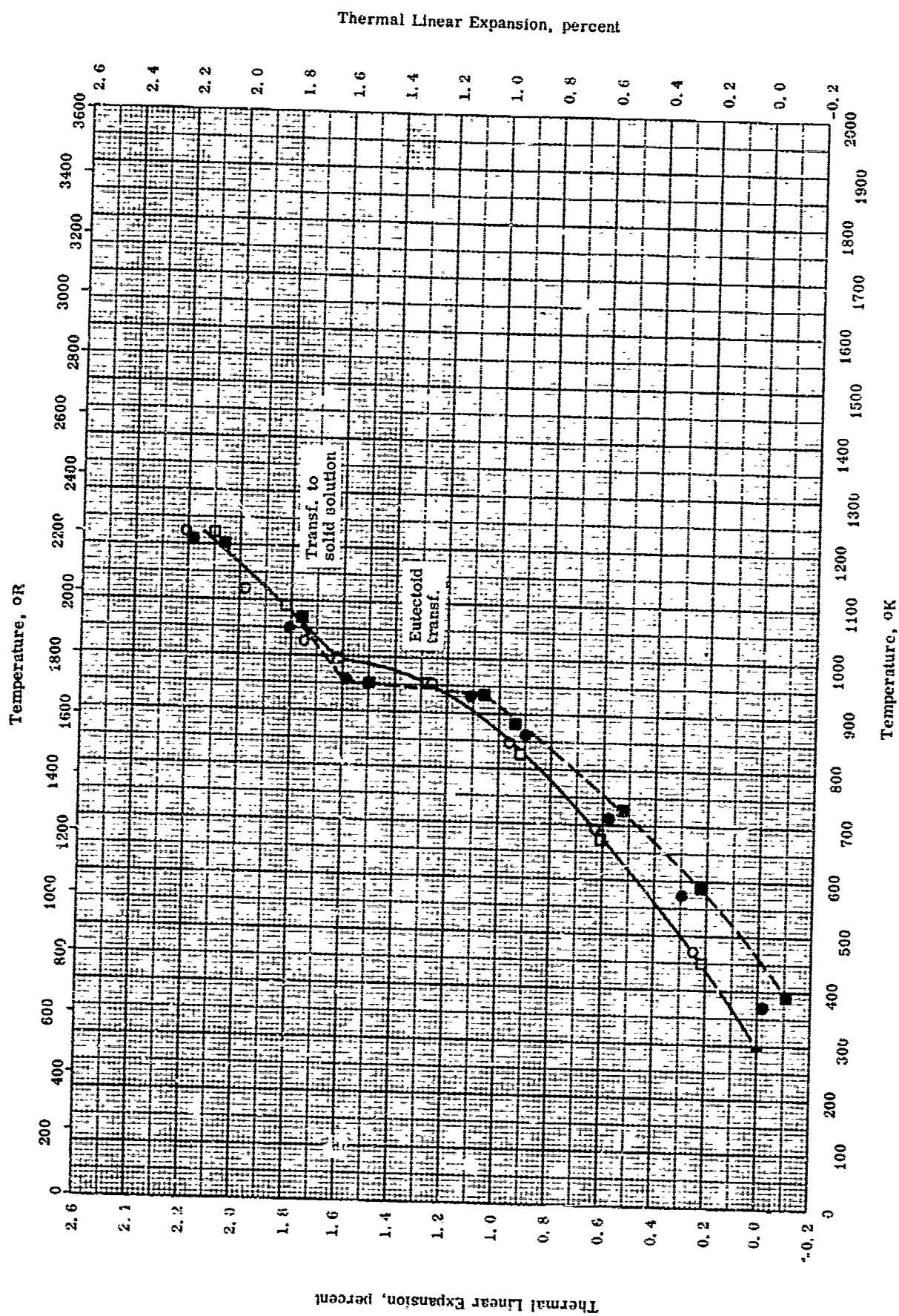
THERMAL CONDUCTIVITY -- URANIUM + ZIRCONIUM

THERMAL CONDUCTIVITY -- URANIUM + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--------------------------|--------------------------------|
| ○ | 58-16 | 293-1073 | < ± 5 | U - 1.5 wt % Zr; 1.5 Zr. | Unclad rod before irradiation. |
| □ | 54-6 | 293-1173 | | 5.0 Zr. | |
| △ | 54-6 | 293-1173 | | 20.0 Zr. | |
| ▽ | 54-6 | 293-1173 | | 40.0 Zr. | |

TPRC



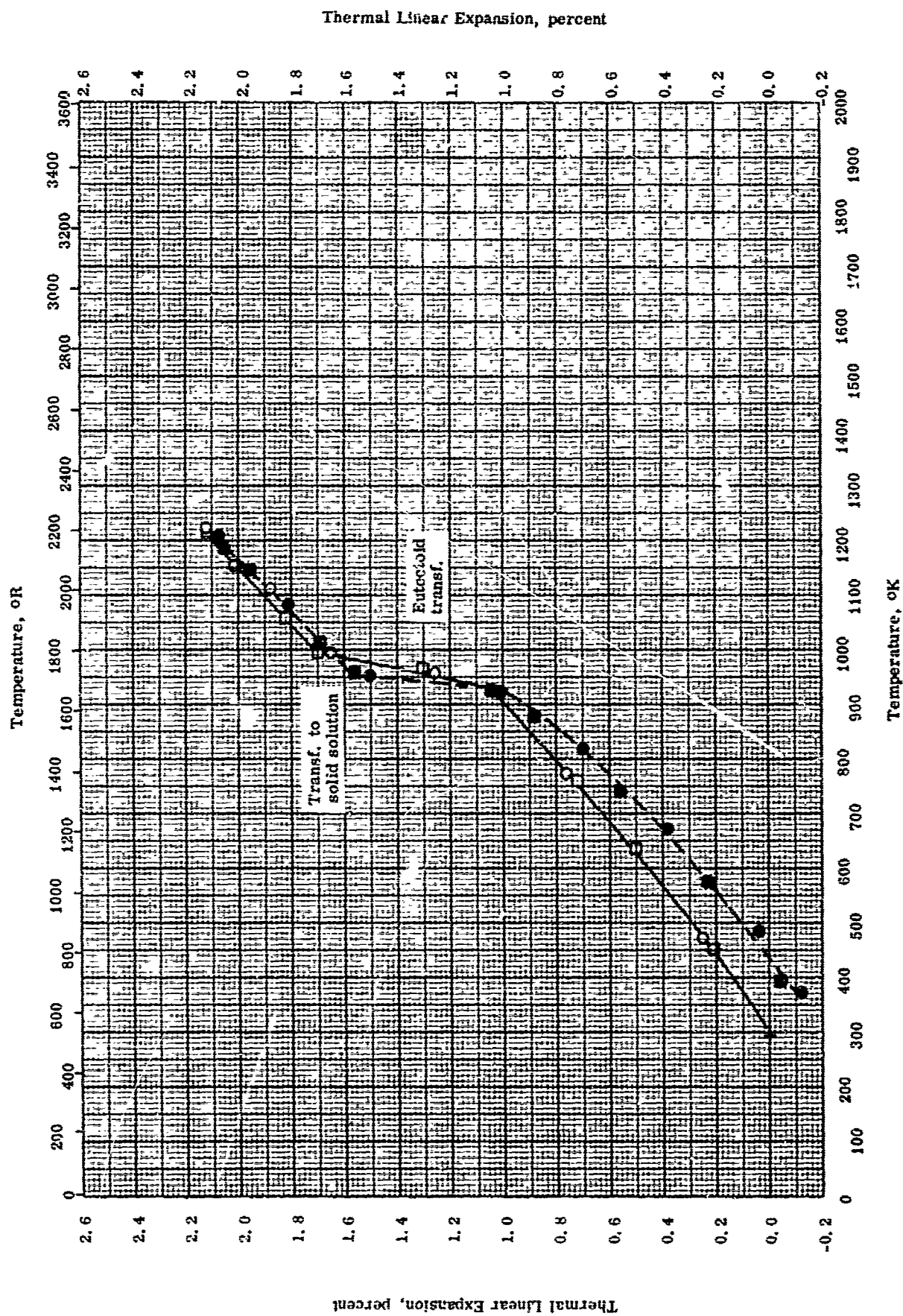
Thermal Linear Expansion -- URANIUM + ZIRCONIUM
(3 Zr)

THERMAL LINEAR EXPANSION -- URANIUM + ZIRCONIUM
(3 Zr)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rupt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 56-45 | 295-1222 | | 2.95 Zr. | Heated 1 hr at 800 C and 24 hrs at 670 C and furnace cooled; heating; tested in vacuum. |
| ● | 56-45 | 373-1222 | | Same as above. | Cooling of the above sample. |
| □ | 56-45 | 295-1222 | | Same as above. | 1 hr at 800 C, isothermally transformed 2 hrs at 550 C, 5 min at 780 C, isothermally transformed 2 hrs at 550 C, 5 min at 780 C, 2 hrs 550 C; heating. |
| ■ | 56-45 | 295-1222 | | Same as above. | Cooling of the above sample. |

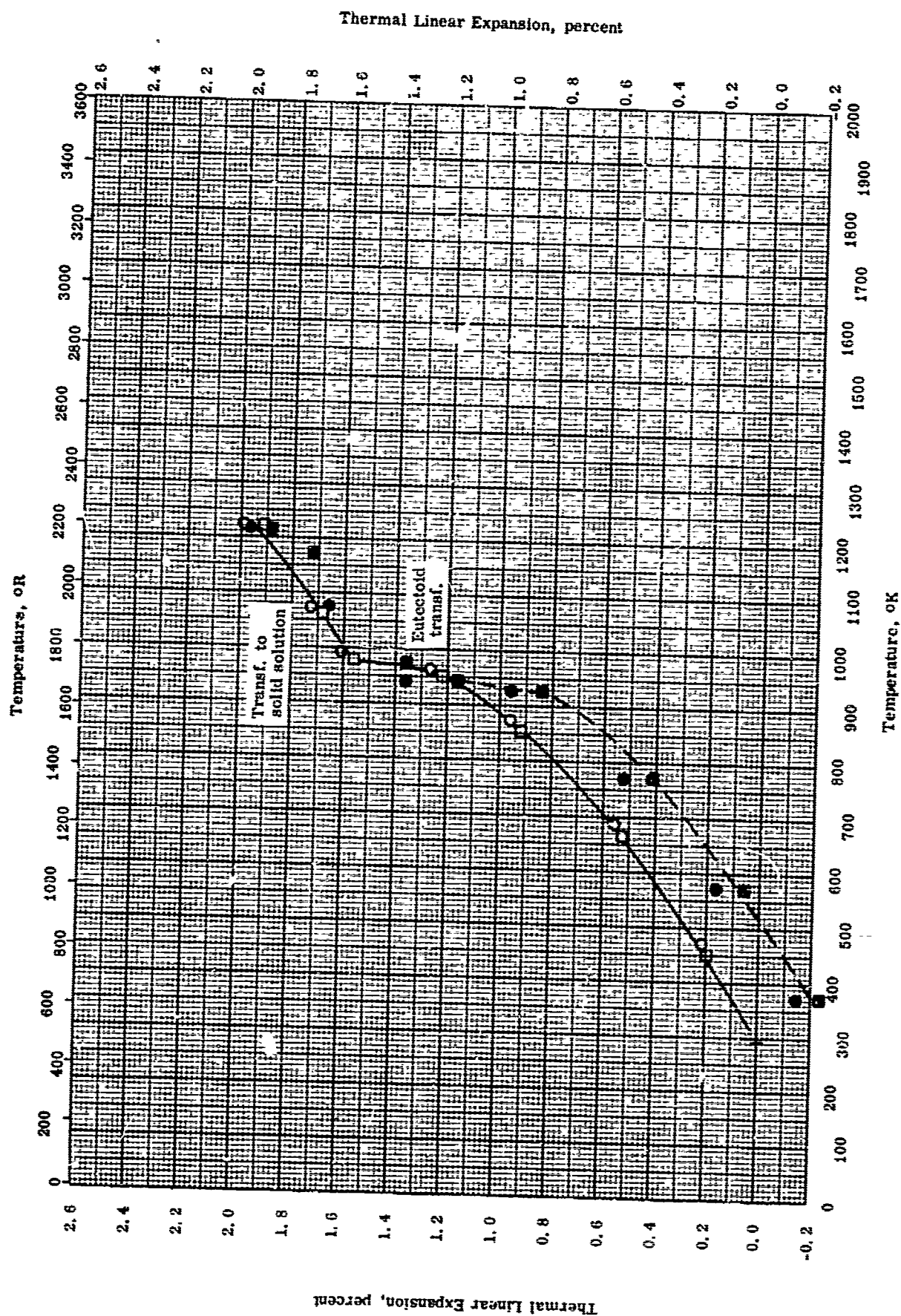
TPRC



THERMAL LINEAR EXPANSION -- URANIUM + ZIRCONIUM
(5 Zr)

REFERENCE INFORMATION

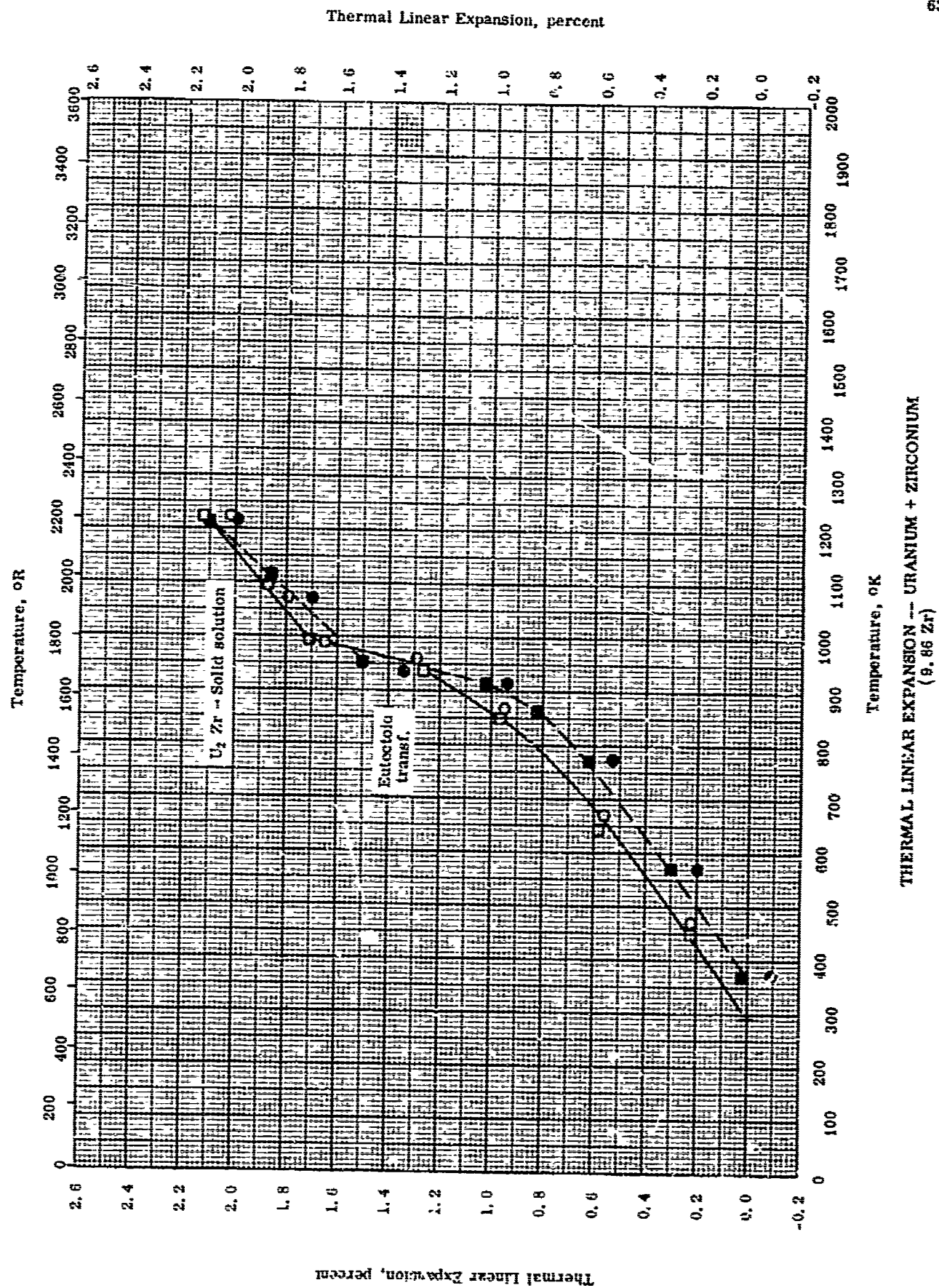
| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 56-45 | 295-1222 | | 4.96 Zr. | Heated 1 hr at 800 C and 24 hrs at 670 C and furnace cooled; heating; tested in vacuum. |
| ● | 56-45 | 373-1222 | | Same as above. | Cooling of the above curve. |
| □ | 56-45 | 295-1222 | | Same as above. | 1 hr at 800 C, isothermally transformed 2 hrs at 550 C, 5 min at 780 C, isothermally transformed 2 hrs at 550 C, 5 min at 780 C, 2 hrs at 550 C; heating; treated in vacuum. |
| ■ | 56-45 | 395-1222 | | Same as above. | Cooling of the above sample. |



THERMAL LINEAR EXPANSION -- URANIUM + ZIRCONIUM
(7.07 Zr)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 56-45 | 293-1222 | | 7.07 Zr. | Heated 1 hr at 800 C and 24 hrs at 670 C, and furnace cooled; heating; tested in vacuum. |
| ● | 56-45 | 373-1222 | | Same as above. | Cooling of the above sample. |
| □ | 56-45 | 293-1222 | | Same as above. | 1 hr at 800 C, isothermally transformed 2 hr at 550 C, 5 min at 780 C, isothermally transformed 2 hrs at 550 C, 5 min at 780 C, 2 hrs at 550 C; heating; tested in vacuum. |
| ■ | 56-45 | 373-1222 | | Same as above. | Cooling of the above sample. |



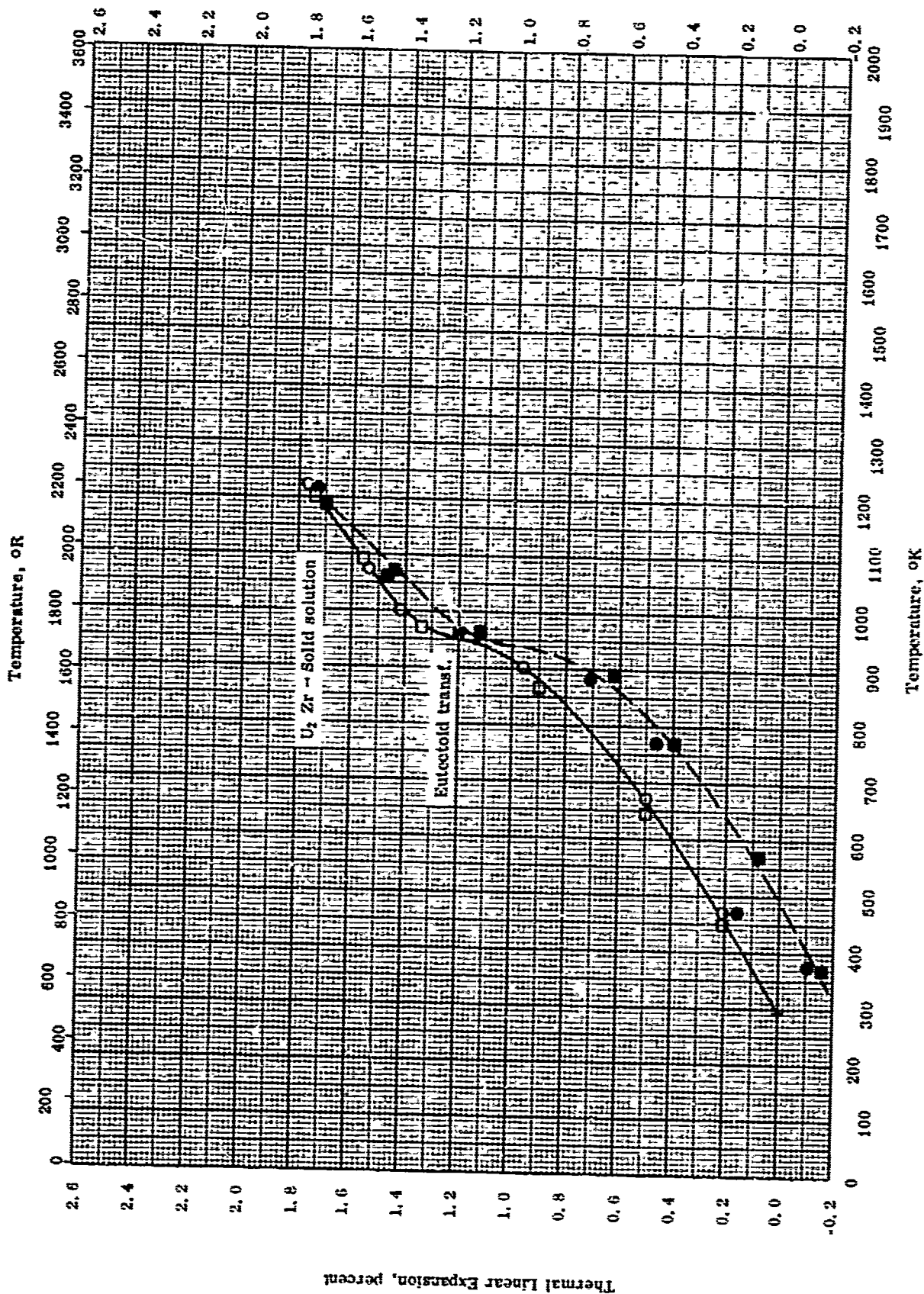
THERMAL LINEAR EXPANSION --- URANIUM + ZIRCONIUM
(9.86 Zr)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rep. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-----------------------|--|
| ○ | 56-45 | 295-1222 | | 9.86 Zr. | 1 hr at 800 C, 24 hrs at 370 C, and furnace cooled; heating; tested in vacuum. |
| ● | 56-45 | 373-1222 | | Same as above. | Cooling of the above sample. |
| □ | 56-45 | 205-1222 | | Same as above. | 1 hr at 800 C, furnace cooled to 750 C, furnace cooled from 750 C to 570 C at 1/2 C min ⁻¹ ; heat- ing; tested in vacuum. |
| ■ | 56-45 | 373-1222 | | Same as above. | Cooling of the above sample. |

Thermal Linear Expansion, percent

639



Thermal Linear Expansion -- URANIUM + ZIRCONIUM
(15.5 Zr)

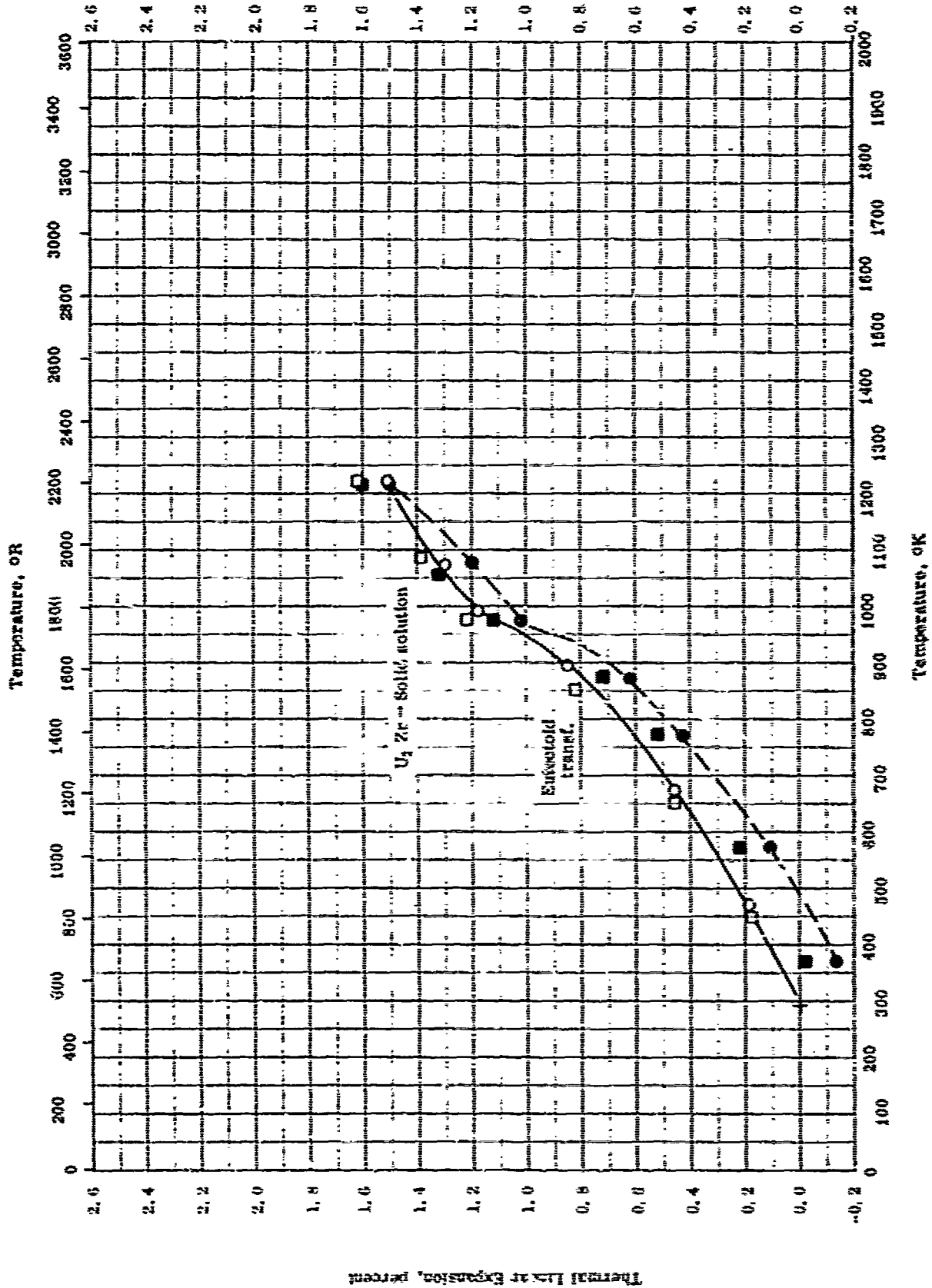
THERMAL LINEAR EXPANSION --- URANIUM + ZIRCONIUM
(15.5 Zr)

REFERENCE INFORMATION

| Sym Set | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 60-45 | 295-1222 | | 15.5 Zr. | Heated 1 hr at 800 C, 24 hrs at 670 C, and furnace cooled; heating; tested in vacuum. |
| ● | 60-45 | 373-1222 | | Same as above. | Cooling of the above sample. |
| □ | 60-45 | 295-1222 | | Same as above. | Heated 1 hr at 800 C, furnace cooled to 750 C, and furnace cooled from 750 C to 570 C at 1/2 C min ⁻¹ , heating; tested in vacuum. |
| ■ | 60-45 | 373-1222 | | Same as above. | Cooling of the above sample. |

Thermal Linear Expansion, percent

641

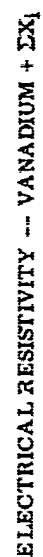


Thermal Linear Expansion -- URANIUM + ZIRCONIUM
(20 Zr)

THERMAL LINEAR EXPANSION -- URANIUM - ZIRCONIUM
(20 Zr)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 56-5 | 293-1222 | | 20 Zr. | 1 hr 800 C, furnace cooled to 750 C, and furnace cooled from 750 C to 570 C at 1/2 C min ⁻¹ , heating; tested in vacuum. |
| ● | 56-45 | 373-1223 | | Same as above. | Cooling of the above sample. |
| □ | 56-45 | 293-1222 | | Same as above. | 1 hr 800 C, isothermally transformed at 500 C for 2 hrs and water quenched; heating; tested in vacuum. |
| ■ | 56-45 | 373-1223 | | Same as above. | Cooling of the above sample. |



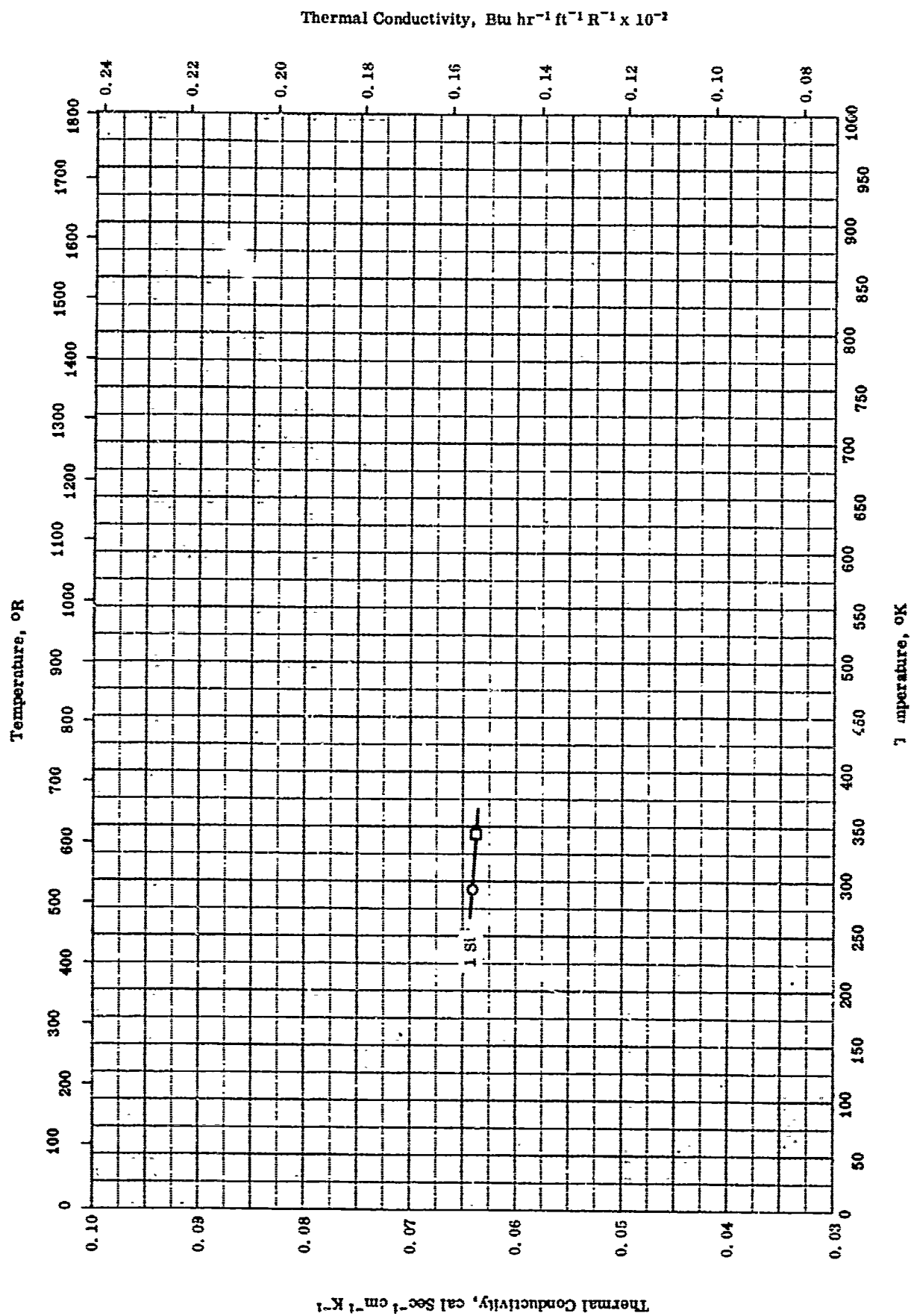
TPRC

ELECTRICAL RESISTIVITY -- VANADIUM + ΣX_i

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|-----------------------------------|
| ○ | 56-16 | 5-304 | ± 10 | 0. 80 Mn. | Accuracy for values at room temp. |
| □ | 56-16 | 5-304 | ± 10 | 0. 94 Ni. | Same as above. |
| △ | 56-16 | 5-304 | ± 10 | 0. 98 Ti. | Same as above. |
| ◇ | 56-16 | 5-304 | ± 10 | 0. 99 Cr. | Same as above. |
| ▽ | 56-16 | 5-304 | ± 10 | 1. 00 Fe. | Same as above. |
| ● | 56-16 | 5-304 | ± 10 | 1. 00 Cu. | Same as above. |
| △ | 56-16 | 5-304 | ± 10 | 1. 09 Zr. | Same as above. |
| ▲ | 56-16 | 5-304 | ± 10 | 2. 05 Pd. | Same as above. |
| ▽ | 56-16 | 5-304 | ± 10 | 2. 12 Sb. | Same as above. |
| ▼ | 56-16 | 5-304 | ± 10 | 2. 30 Sn. | Same as above. |
| ⊙ | 56-16 | 5-304 | ± 10 | 0. 60 Al. | Same as above. |
| ■ | 56-16 | 304 | ± 10 | 1. 61 Al. | Same as above. |
| ▲ | 56-16 | 304 | ± 10 | 9. 97 Al. | Same as above. |
| ◆ | 56-16 | 304 | ± 10 | 15. 00 Al. | Same as above. |

TPRC



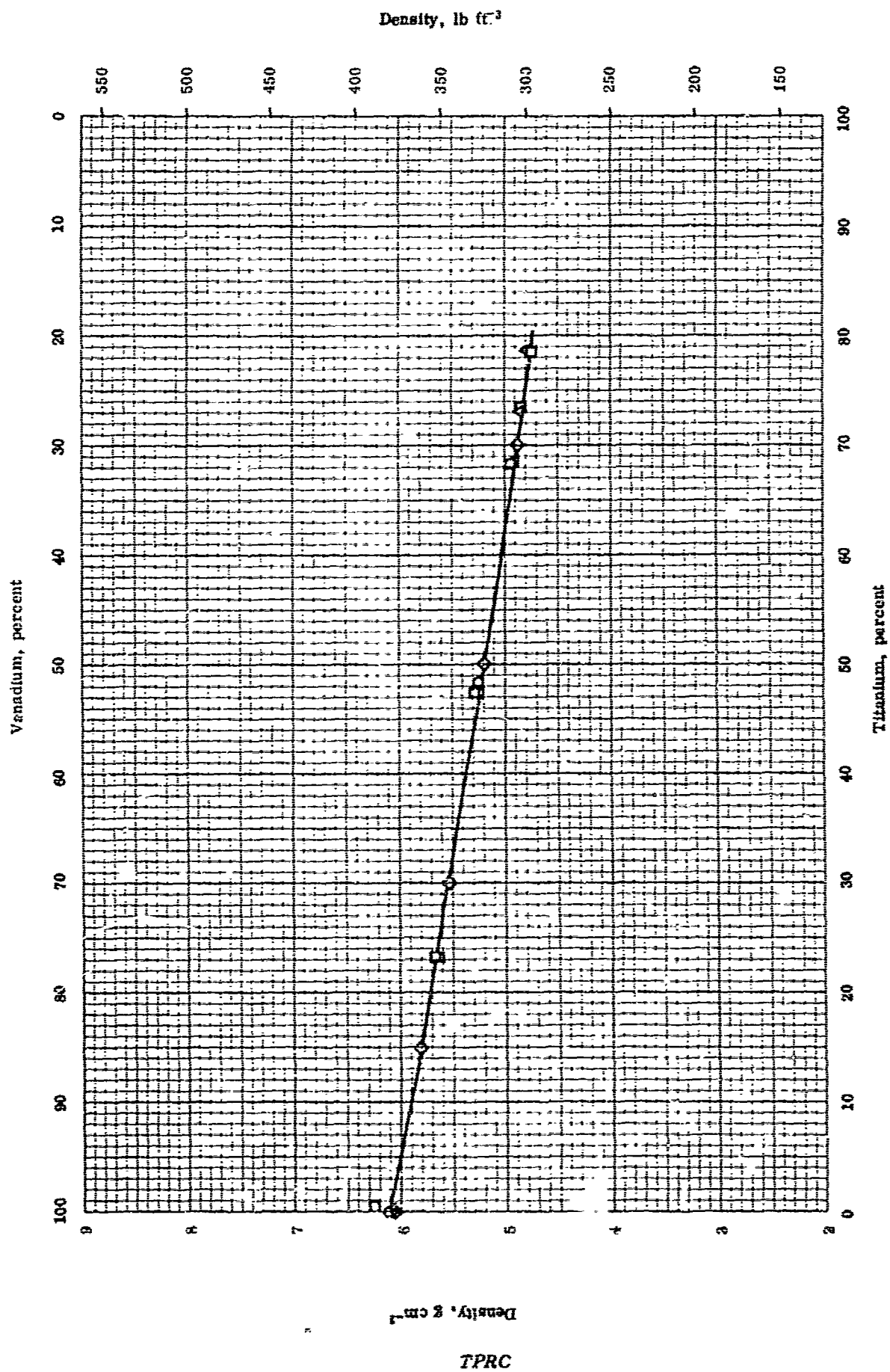
THERMAL CONDUCTIVITY -- VANADIUM + SILICON

THERMAL CONDUCTIVITY -- VANADIUM + SILICON

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|--|--|
| ○ | 57-5 | 293 | | 1 Si. | Alloy formed by arc melting raw materials and remelted several times without opening furnace to insure homogeneity; forged and machined. |
| □ | 55-5 | 343 | ±3 | 1 Si; calcium-reduced 99.6% V and 99+ Ti; homogeneous. | |

TPRC



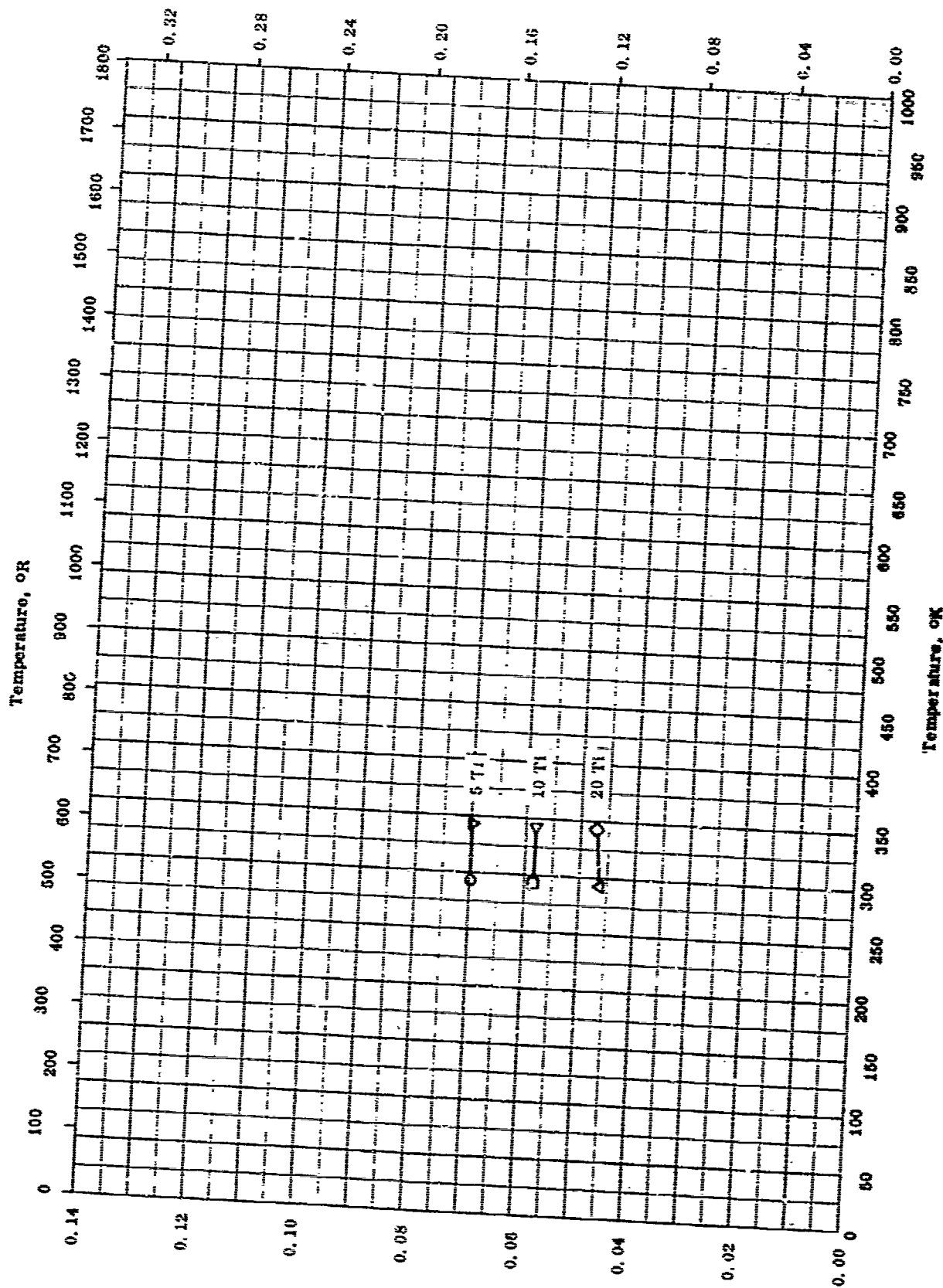
DENSITY -- VANADIUM + TITANIUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--------------------------|--|
| ○ | 52-12 | 298 | | 0-48 Ti; 0.4 impurities. | Density by weight in air and in water. |
| □ | 52-12 | 298 | | 0-78 Ti; 1.8 impurities. | Hot-rolled; same as above. |
| △ | 52-12 | 298 | | 0-78 Ti; 1.8 impurities. | Are-melted; same as above. |
| ◇ | 52-12 | 298 | | 0-70 Ti. | Density computed from X-ray measurements of lattice. |

Thermal Conductivity, $\text{Btu hr}^{-1} \text{ft}^{-1} \text{R}^{-1} \times 10^{-2}$

649



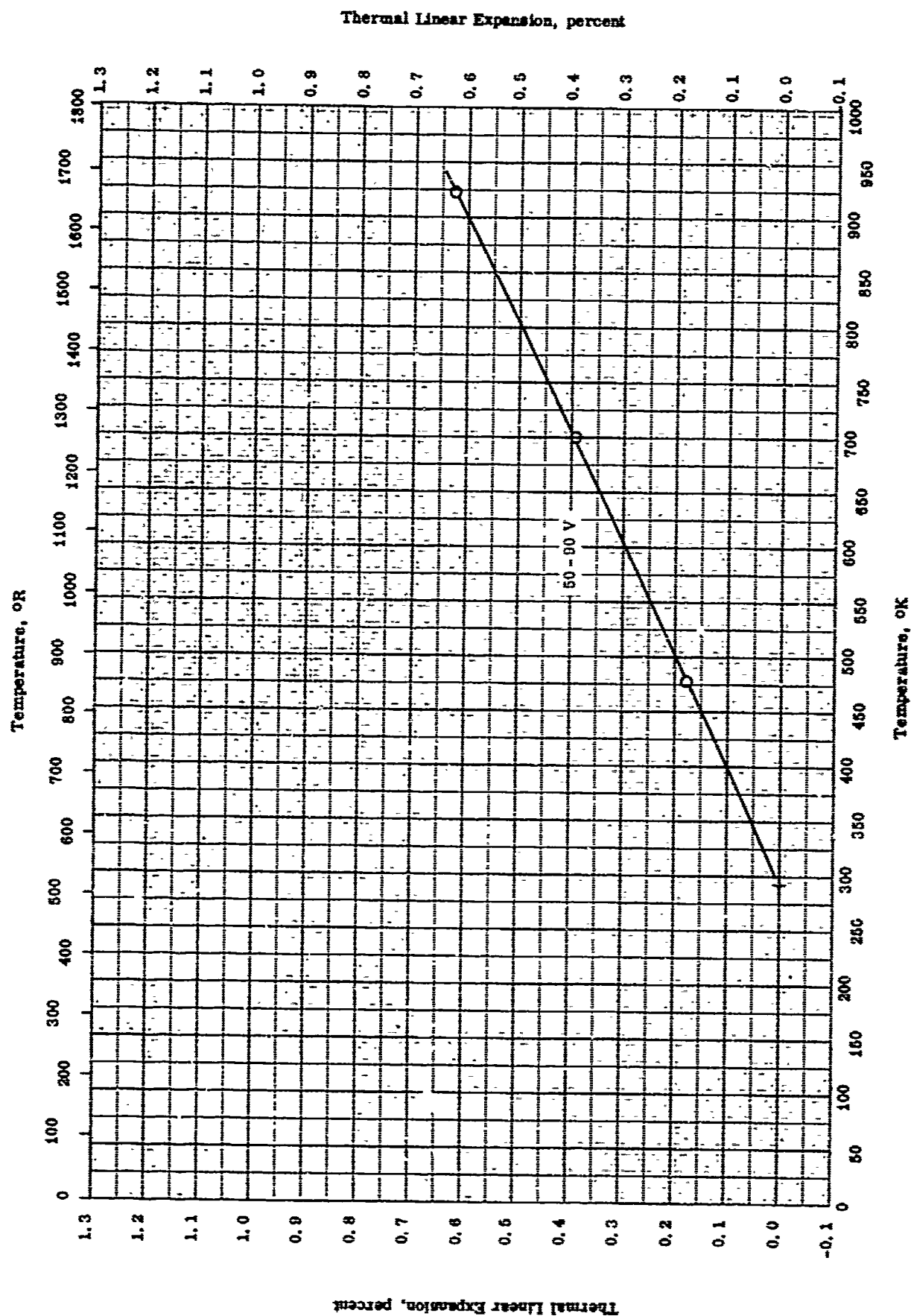
THERMAL CONDUCTIVITY -- VANADIUM + TITANIUM

TPRC

THERMAL CONDUCTIVITY --- VANADIUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|---|--|
| ○ | 57-5 | 298 | | 5 Ti. | Alloy fo. med by arc melting raw materials and remelted several times without opening furnace to insure homogeneity; forged and then machined. Same as above. Same as above. |
| □ | 57-5 | 298 | | 10 Ti | |
| △ | 57-5 | 298 | | 20 Ti. | |
| ▽ | 55-5 | 343 | ±3 | 5 Ti; calcium-reduced 90.6% V and 99.4 Ti; homogeneous. | |
| ◁ | 55-5 | 343 | ±3 | Same as above except 10 Ti. | |
| ◇ | 55-5 | 343 | ±3 | Same as above except 20 Ti. | |

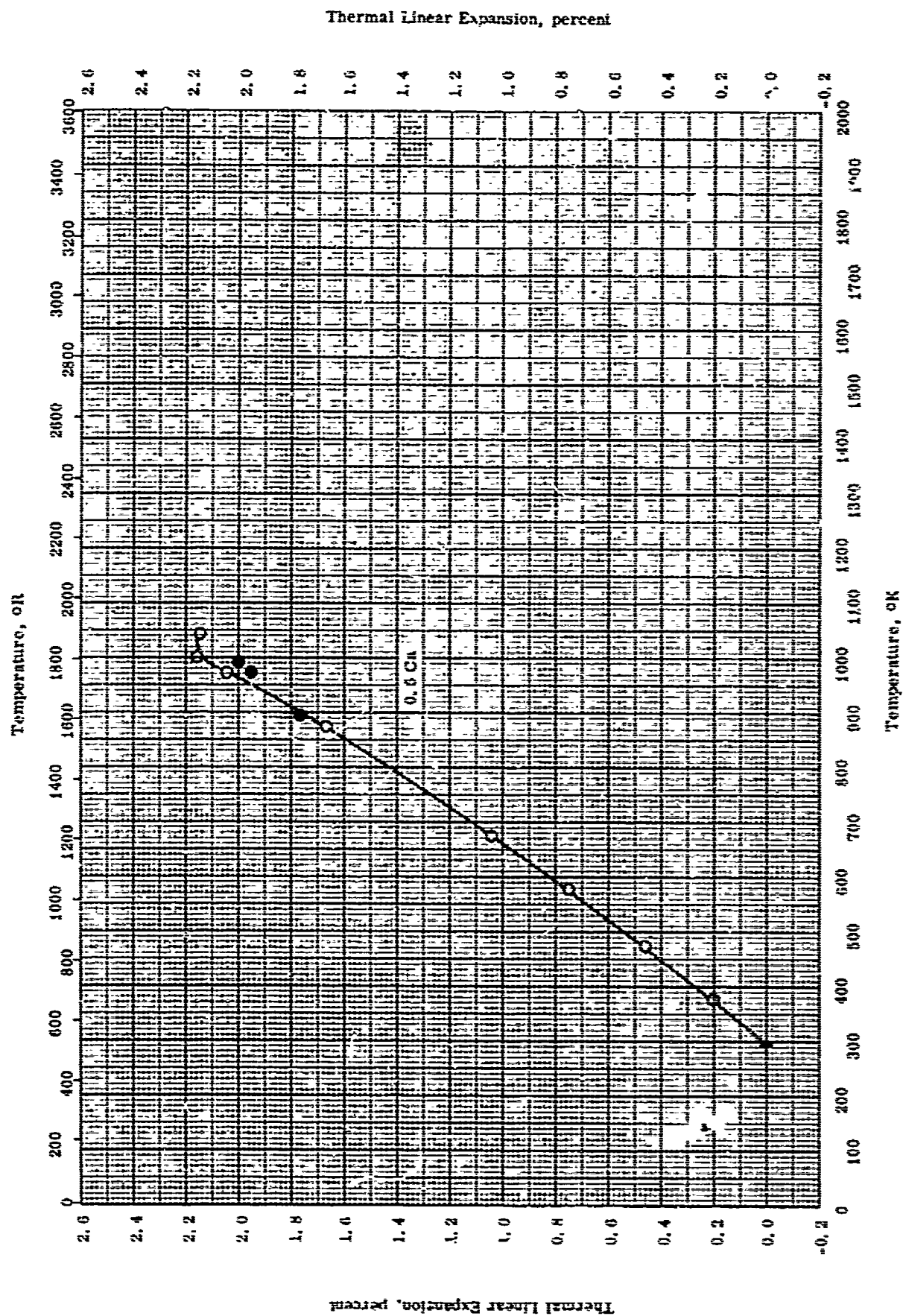


THERMAL LINEAR EXPANSION -- VANADIUM + TITANIUM

THERMAL LINEAR EXPANSION -- VANADIUM + TITANIUM

REFERENCE INFORMATION

| Sym fol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 52-24 | 293-922 | | 50 - 90 V; alloys prepared from 99.9 + pure Ti and 99.8 pure V. | Cast, cold rolled, vac. annealed; average of 4 samples with 50, 60, 70, and 90 V, respectively; Max deviation $\pm 1\%$; tested in vacuum. |



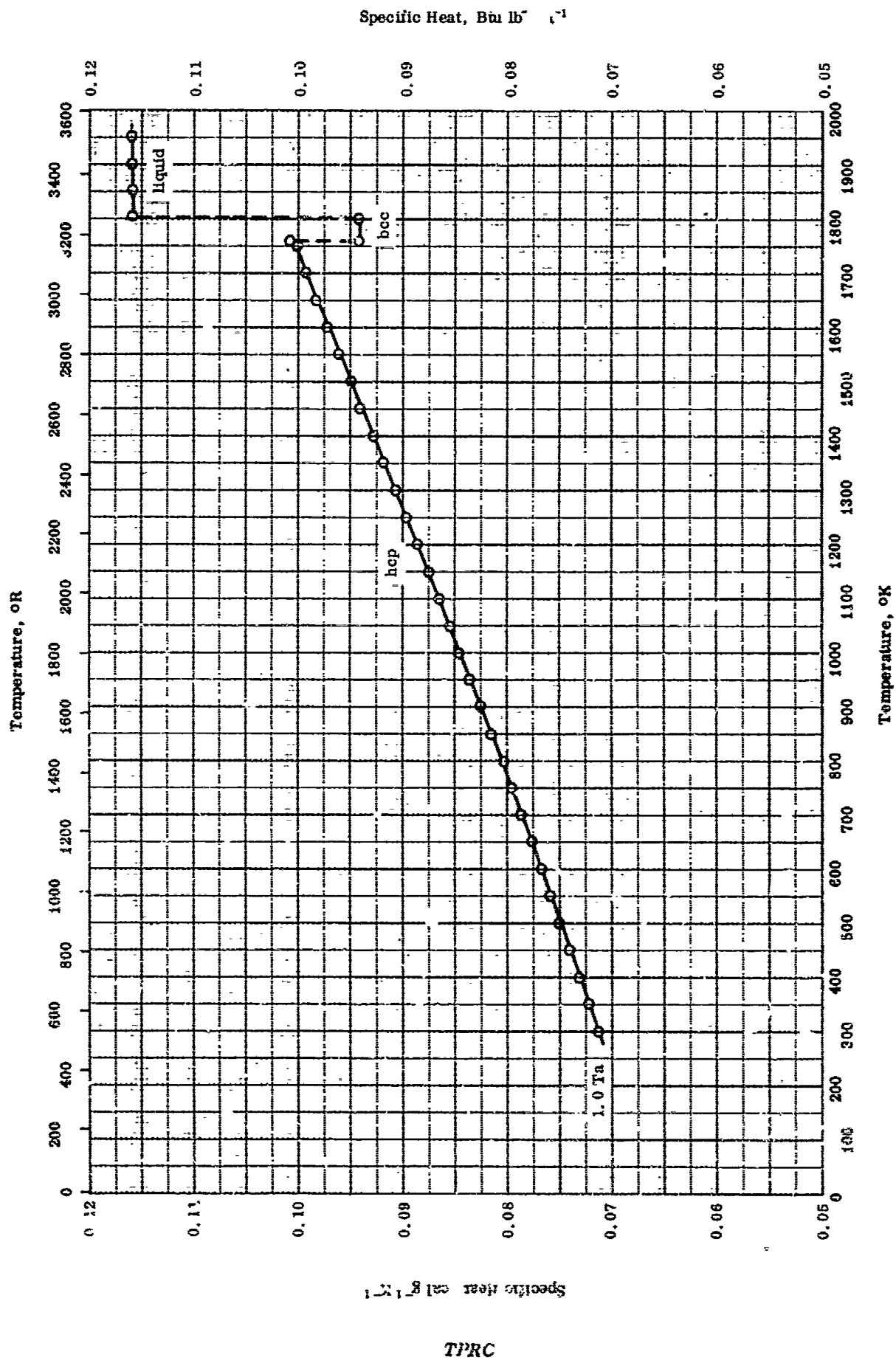
THERMAL LINEAR EXPANSION -- YTTERBIUM + CALCIUM

THERMAL LINEAR EXPANSION -- YTTERBIUM + CALCIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|--|--|
| O | 56-42 also 57-51 | 293-1043 | | 99.3 pure, 0.5 Ca, 0.06 C, 0.05 Fe, Si each, 0.03 Ta, 0.01 Ti, Fe, N each, 0.005 Lu, and trace of Cu. | Reduced ytterbium oxide with La, γ sintered metal, cast into rod; heating; tested in helium. |
| • | 57-51 | 293-1043 | | Same as above. | The above specimen, cooling; results same below 1600 R as of heating. |

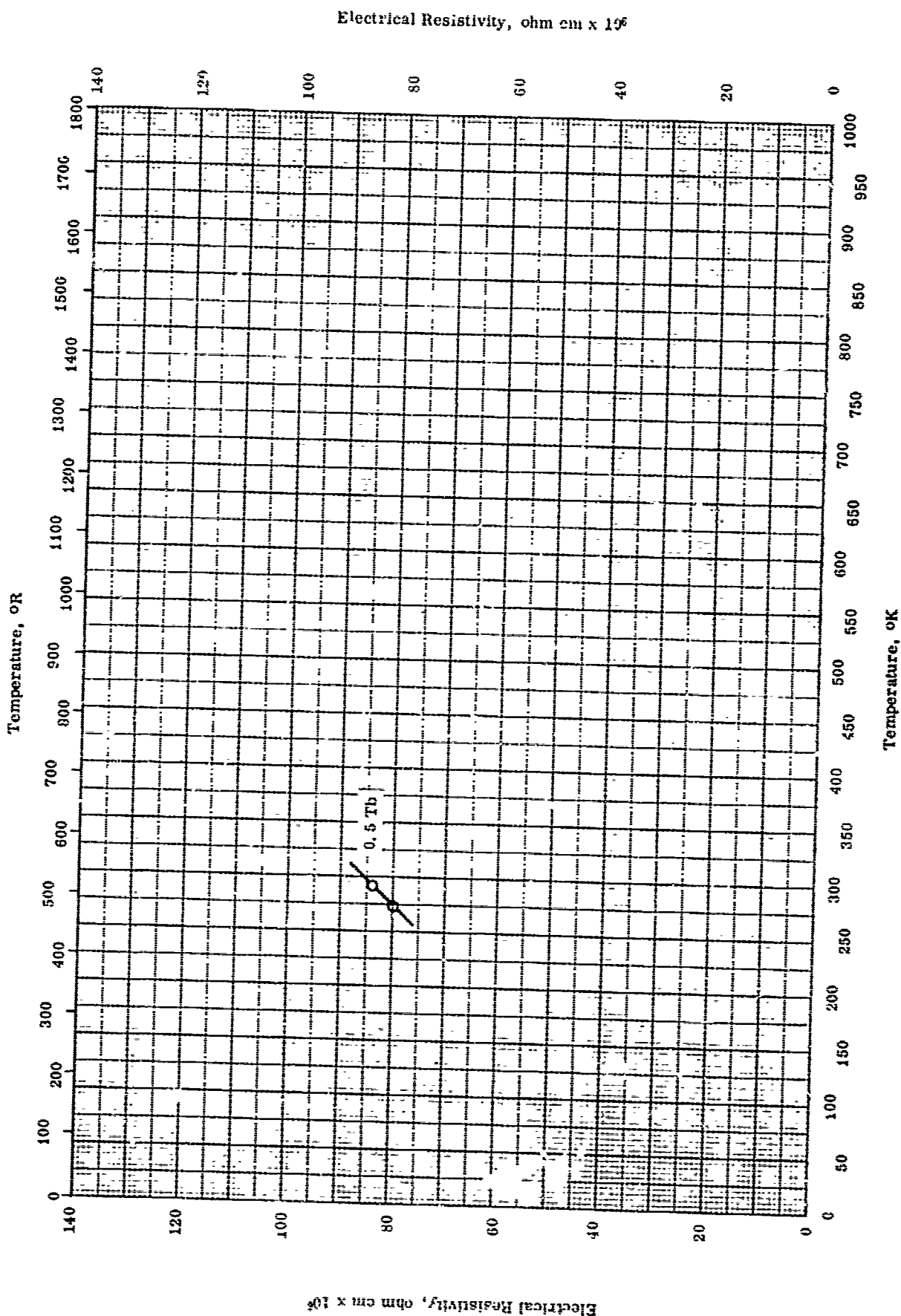
TPRC



SPECIFIC HEAT -- YTTRIUM + TANTALUM

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|------------------------|-------------------|------------------|---|--|
| O | 62-14 also 61-15 | 273-1948 | | >98.76 Y, >1.0 Ta, 0.10 V, <0.05 Ca, <0.05 Er, <0.05 Ho, <0.05 Yb, 0.025 O ₂ , <0.01 Fe, <0.01 Gd, <0.001 Si, 0.0077 C, 0.0070 N ₂ , <0.005 Dy, and <0.005 Mg; crystalline. | Pressed into 1/2-in. dia. rod; sealed under reduced pressure of helium. |

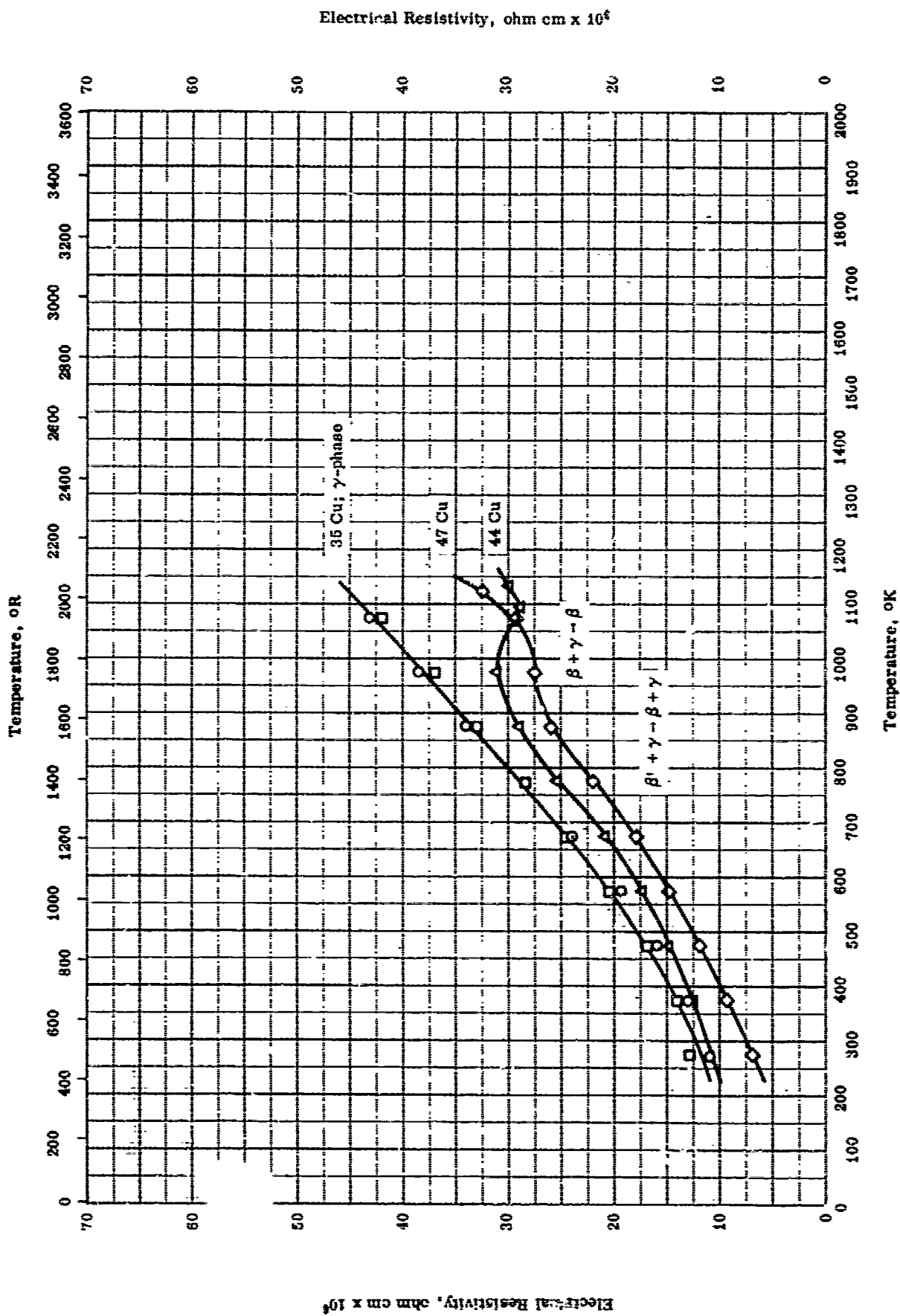


ELECTRICAL RESISTIVITY -- YTTRIUM + TERBIUM

ELECTRICAL RESISTIVITY -- YTTRIUM + TERBIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| O | 55-22 | 273-293 | | 0.5 Tb, 0.2 Dy, 0.1 Er, trace of Fe, weak traces of Al, Ca, Mg, Si, and no Ho. | Annealed to red heat in Ho atmos. after shearing. |



ELECTRICAL RESISTIVITY -- ZINC + COPPER

ELECTRICAL RESISTIVITY -- ZINC + COPPER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---------|
| ○ | 57-25 | 273-1073 | | 05 Zn and 35 Cu. | |
| □ | 67-25 | 273-1073 | | 02 Zn and 38 Cu. | |
| △ | 67-25 | 273-1133 | | 50.5 Zn and 43.5 Cu. | |
| ◇ | 67-26 | 273-1123 | | 53 Zn and 47 Cu. | |

PROPERTIES OF ZINC + SILVER

REPORTED VALUES

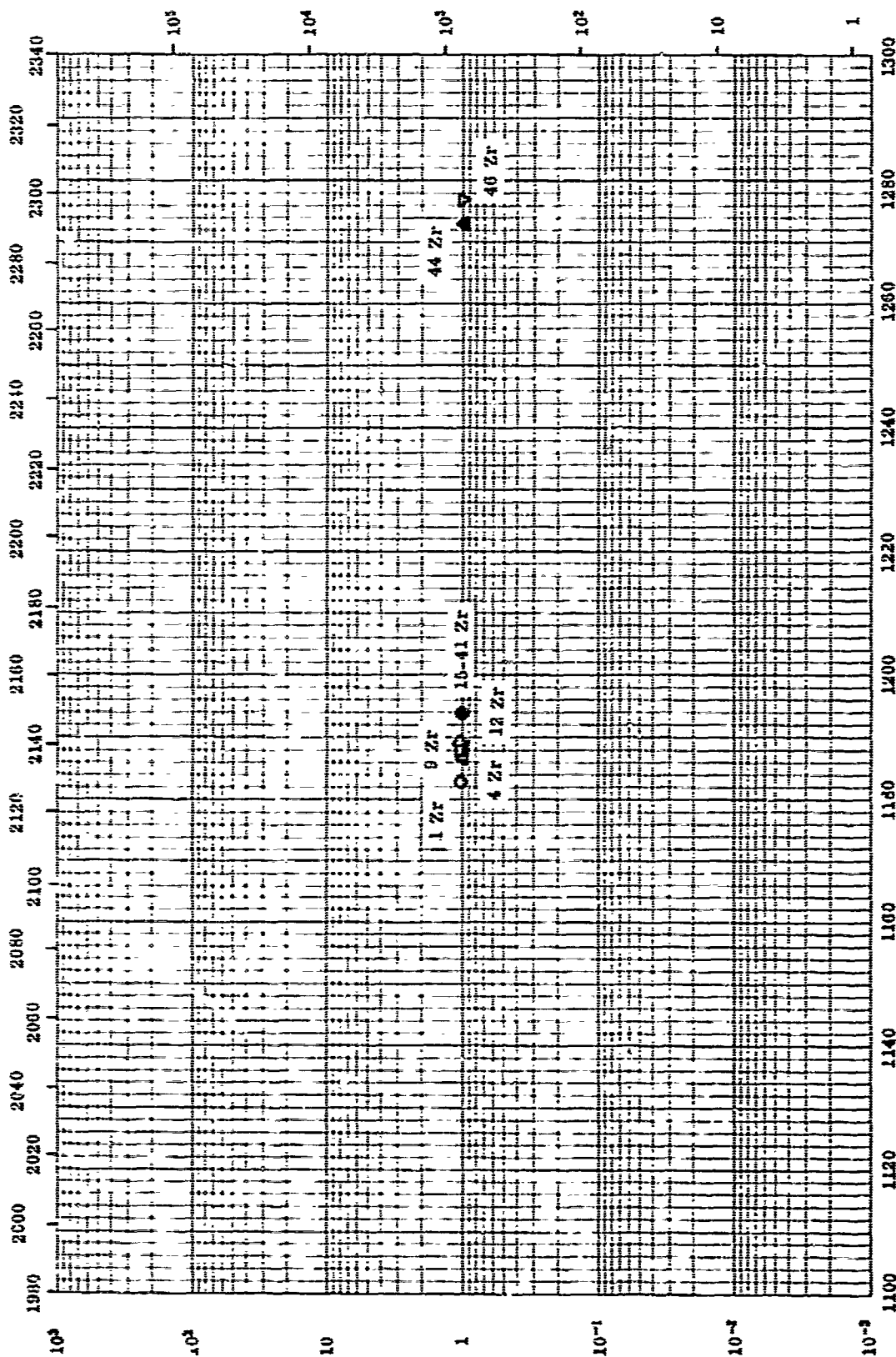
| Melting Point: | K | R |
|-----------------|---------------------|----------------------|
| ○ 39 Ag | 905 | 1630 |
| Heat of Fusion: | cal g ⁻¹ | Btu lb ⁻¹ |
| □ 39 Ag | 27.1 ± 1.3 | 48.7 ± 2.3 |

PROPERTIES OF ZINC + SILVER

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error, % | Sample Specifications | Remarks |
|------------|------|--------------------|-------------------|-------------------------------------|--|
| O | 43-4 | 905 | | 61 Zn and 39 Ag; ϵ -phase. | M.P. from peak in time-temperature curve. |
| □ | 43-4 | 905 | ± 2.3 | Same as above. | ΔH , from enthalpy difference of solid and liquid. |

Temperature, °R



Vapor Pressure, mm Hg

Vapor Pressure, atm.

TPRC

Temperature, °K

VAPOR PRESSURE --- ZINC + ZIRCONIUM

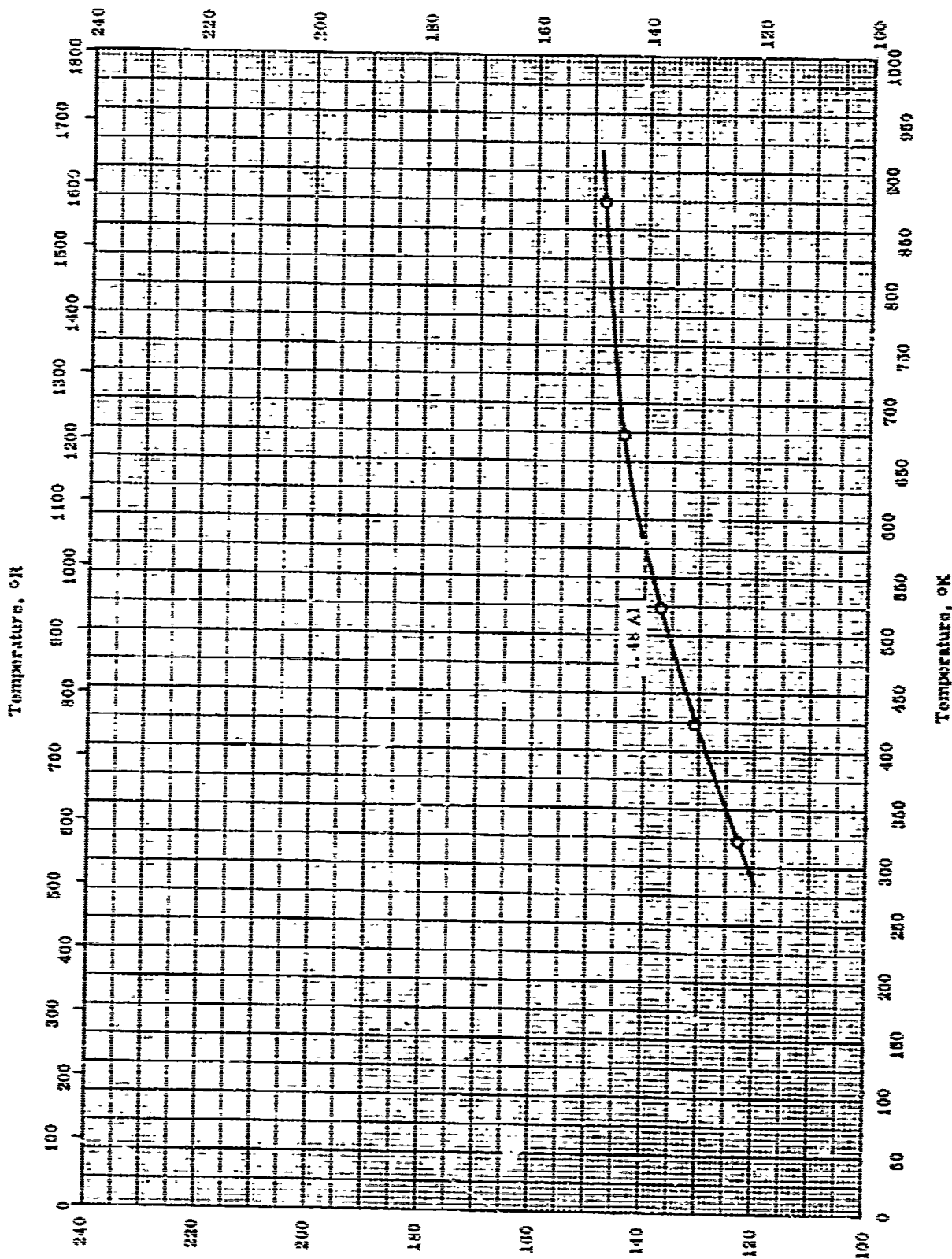
VAPOR PRESSURE -- ZINC + ZIRCONIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Repl. Error, % | Sample Specifications | Remarks |
|------------|-------|--------------------|-------------------|--|--|
| ○ | 50-13 | 1183 | | 1.08 Zr. | Measured temp. at which Zn pressure was 1 atm. |
| △ | 50-13 | 1187 | | 4.0 Zr. | Same as above. |
| □ | 50-13 | 1108 | | 2 alloys: 6.74 Zr and 9.0 Zr. | Same temp. for both alloys. |
| ◇ | 50-13 | 1109 | | 12.0 Zr. | Same as above. |
| ● | 50-13 | 1106 | | 4 alloys: 15.0 Zr, 23.73 Zr, 24.7 Zr, 41 Zr. | Same temp. for the 4 alloys. |
| ▽ | 50-13 | 1277 | | 44 Zr. | Same as above. |
| ▲ | 50-13 | 1273 | | 46 Zr. | Same as above. |

Electrical Resistivity, ohm cm x 10⁴

665



ELECTRICAL RESISTIVITY -- ZIRCONIUM + ALUMINUM

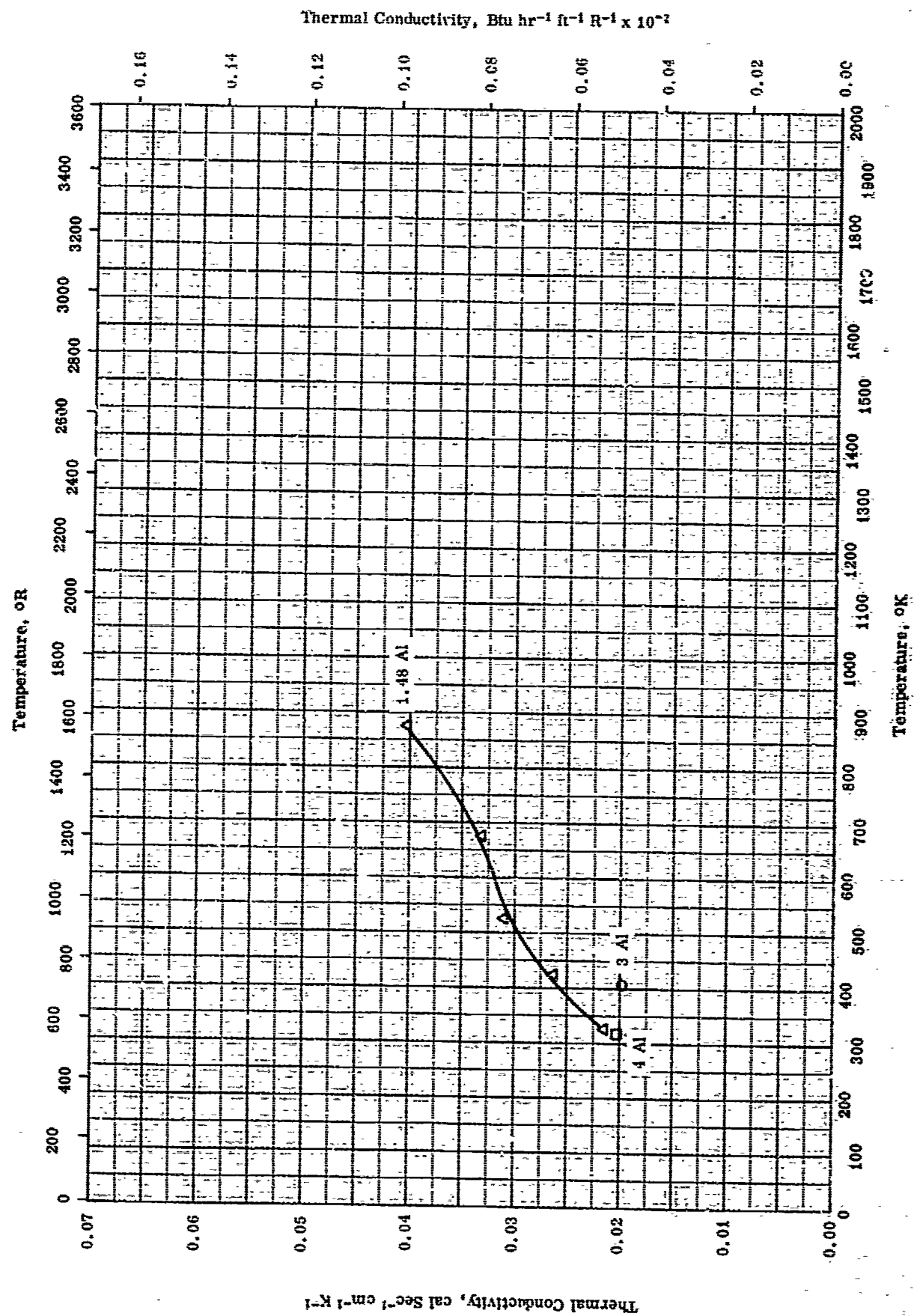
TPRC

ELECTRICAL RESISTIVITY -- ZIRCONIUM + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|-----------|
| O | 61-12 | 323-873 | 5 | 1.43 Al, 0.14 C, 0.11 Fe, 0.10 O ₂ , and 0.0045 N ₂ ; prepared by graphite-melted Zr. | Extruded. |

TPRC



THERMAL CONDUCTIVITY - ZIRCONIUM + ALUMINUM

THERMAL CONDUCTIVITY -- ZIRCONIUM + ALUMINUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|-----------|
| ○ | 56-11 | 373-407 | | 3 Al. | Extruded. |
| □ | 54-5 | 319 | | 4 Al. | |
| △ | 61-12 | 323-873 | | 1.48 Al, 0.14 C, 0.11 Fe, 0.10 O ₂ , 0.0045 N ₂ ; graphite-molten Zr as raw material. | |

TPRC

PROPERTIES OF ZIRCONIUM + BORON

REPORTED VALUES

| Density: | | g cm^{-3} | lb ft^{-3} |
|----------|--------|--------------------|---------------------|
| O | 0.44 B | 6.5055 | 406.13 |
| □ | 0.78 B | 6.4940 | 405.41 |
| △ | 1.21 B | 6.4796 | 404.51 |
| ▽ | 1.77 B | 6.4489 | 402.59 |

PROPERTIES OF ZIRCONIUM + BORON

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 57-38 | 298 | | 0.44 B. | Alloy made by 2 consumable electrode melts in sequence in arc furnace with He atm and extruded repeatedly; average value of 2-4 test each from weight and volume by CCl_4 displacement. |
| □ | 57-38 | 298 | | 0.78 B. | Same as above. |
| △ | 57-38 | 298 | | 1.21 B. | Same as above. |
| ▽ | 57-38 | 298 | | 1.77 B. | Same as above. |

PROPERTIES OF ZIRCONIUM + HAFNIUM

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|----------------------|---------------------|----------------------|
| □ 2.4 Hf | 6.565 | 409.8 |
| Δ 2.4 Hf; annealed | 6.566 | 409.9 |
| ▽ 0.2 Hf | 6.49 | 405 |
| Heat of Sublimation: | cal g^{-1} | Btu lb^{-1} |
| ◇ 1.92 Hf | $1558 \pm 3.8_{0K}$ | $2805 \pm 6.9_{0R}$ |

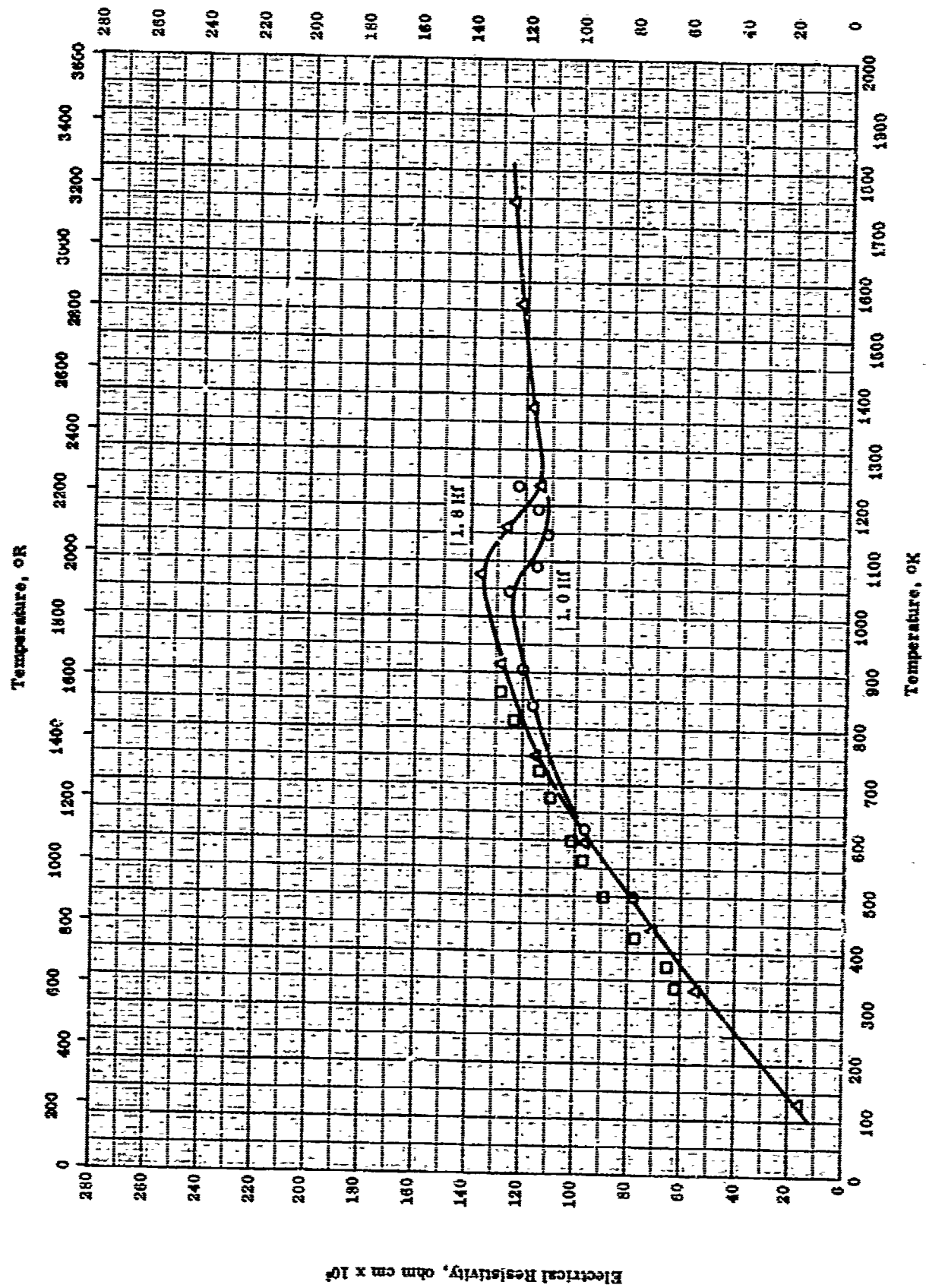
PROPERTIES OF ZIRCONIUM + HAFNIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ◇ | 51-12 | 0 | | 1.92 Hf, 0.10 W, and 0.11 others (including Al and Si). | Δh_f from vapor pressure data |
| □ | 51-13 | 298 | | 2.4 Hf, 0.115 Fe, 0.039 O ₂ , 0.022 Si, 0.010 > Mg, 0.009 Ti, 0.008 Al, 0.007 N ₂ , 0.005 > Cr, 0.005 > Ni, 0.002 Mn, and 0.002 Ca. | Density from x-ray lattice measurements |
| △ | 54-23 | 293 | | 97.4 Zr and 2.4 Hf. | Annealed; density from x-ray lattice measurements. |
| ▽ | 47-4 | 298 | | 0.2 Hf and small amount of O, N, H, and C. | Density computed from x-ray lattice measurements. |

Electrical Resistivity, ohm cm x 10⁴

673



ELECTRICAL RESISTIVITY -- ZIRCONIUM + HAFNIUM

TPRC

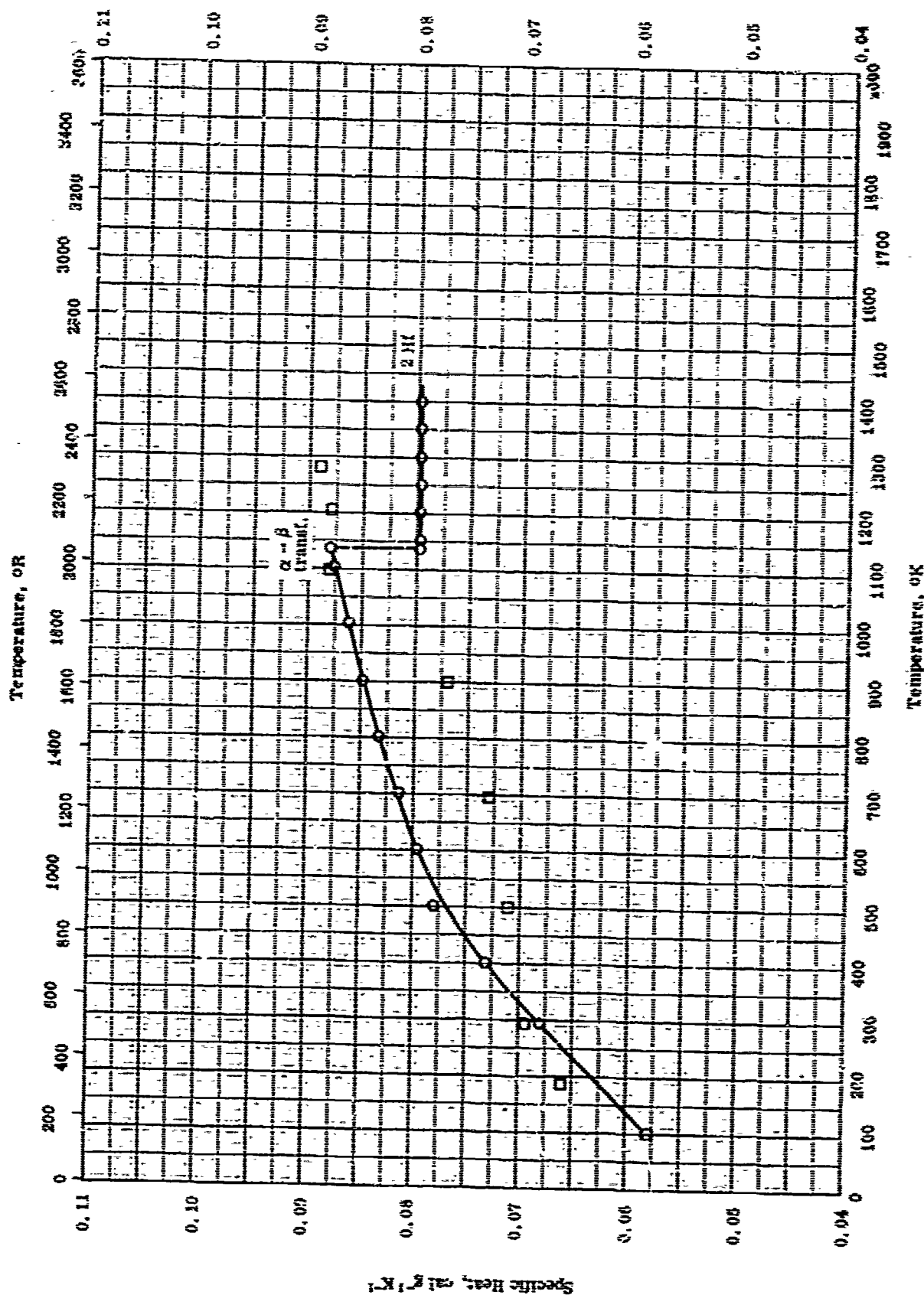
ELECTRICAL RESISTIVITY -- ZIRCONIUM + HAFNIUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|--------------------|------------------|---|---|
| ○ | 41-2 | 300-1200 | | 1 Hf and 0.11 Fe; large crystals of ductile material. | Annealed in vacuum after swaging; tested in vacuum. |
| △ | 50-7 | 73-1773 | | 1.8 Hf, 0.05 each Fe, Ta, 0.03 Si, 0.005 each Ti, Cr, 0.005 > Cu, 0.003 Al, 0.002 Ni, 0.001 each Mg, Pb, Mo, 0.001 > each Co, Mn, and C, 0.005 Cu; foote crystal bar. | Annealed above recrystallization temp. |
| □ | 57-7 | 330-804 | | 0.97 Hf and 0.3 Co. | Annealed 2 hrs at 760 °C and water-quenched. |

Specific Heat, Btu lb⁻¹ R⁻¹

675



SPECIFIC HEAT -- ZIRCONIUM & HAFNIUM

SPECIFIC HEAT -- ZIRCONIUM + HAFNIUM

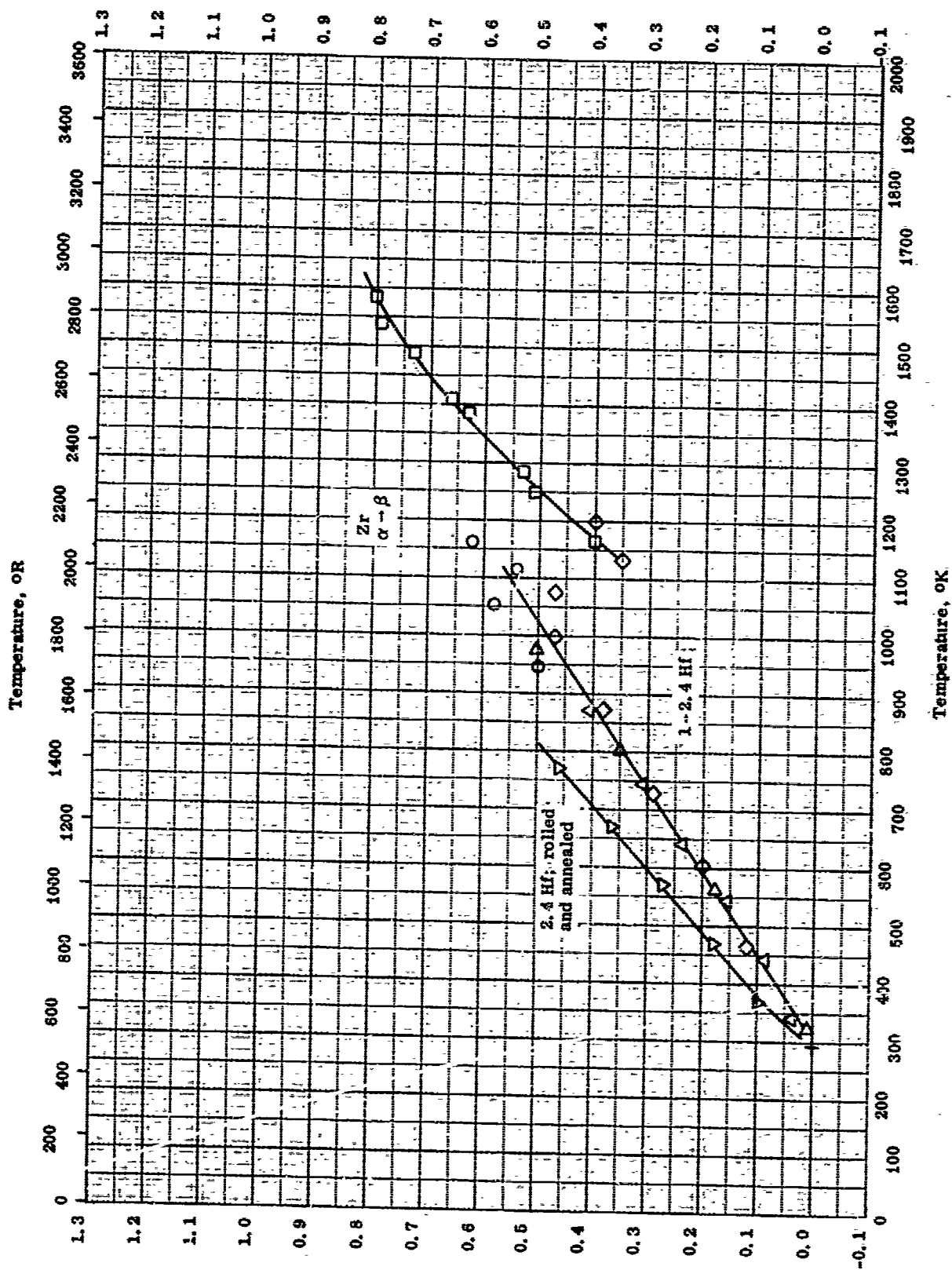
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|-------------------------------------|
| ○ | 50-5 | 298-1400 | | 2.15 Hf. | Large crystals of ductile material. |
| □ | 41-2 | 100-1280 | | 1.0 Hf, 0.11 Fe. | |

TPRC

Thermal Linear Expansion, percent

877



Thermal Linear Expansion --- ZIRCONIUM + HAFNIUM

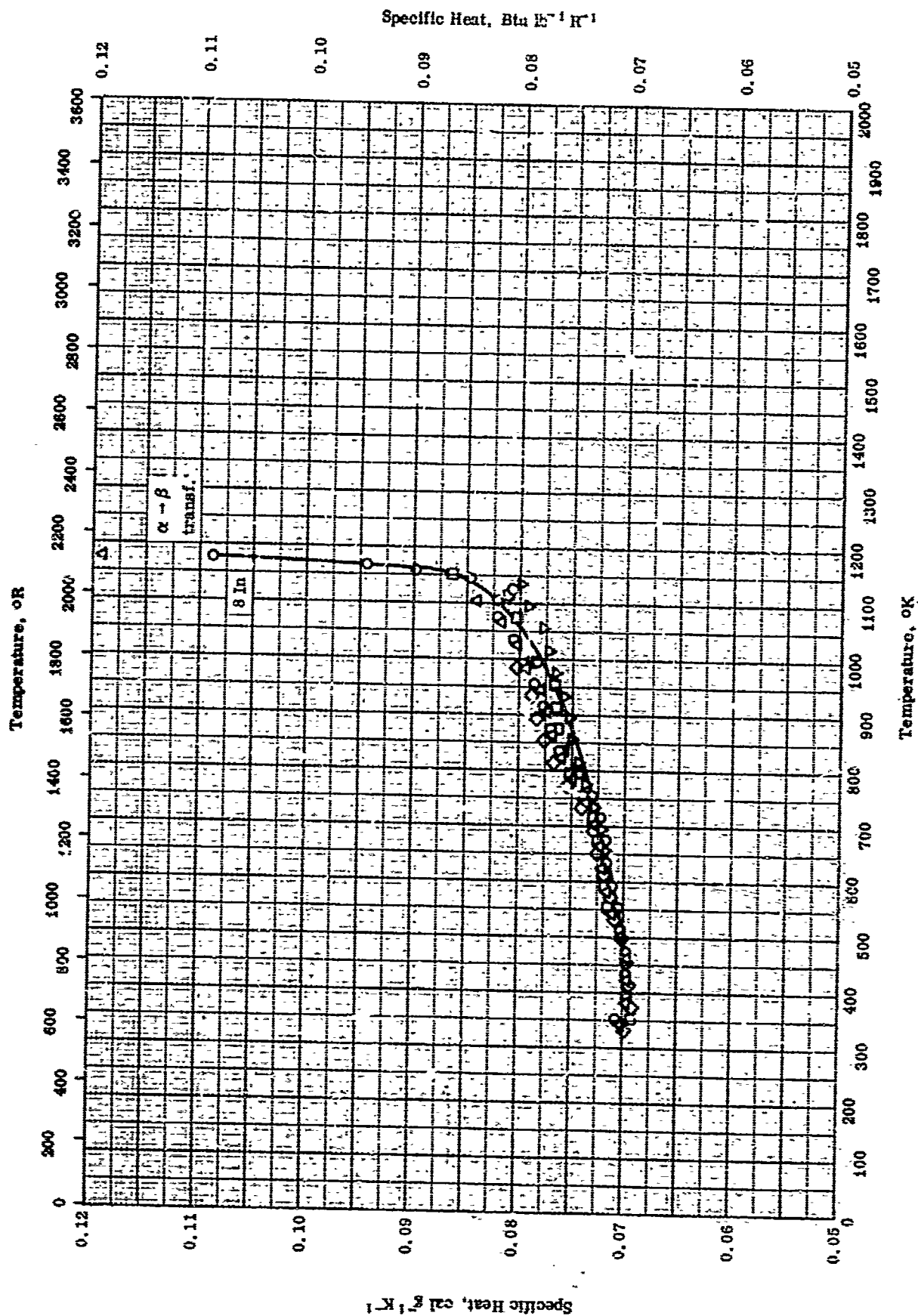
Thermal Linear Expansion, percent

TPRC

THERMAL LINEAR EXPANSION -- ZIRCONIUM + HAFNIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 53-27 | 950-1164 | 10-14 | α - Zr; hexagonal; 1.92 Hf, 0.10 W, and 0.4 others including Si and Al (assuming at wt. of others is 100). | |
| □ | 53-27 | 1166-1584 | 7 | β - Zr; cubic; same composition as above. | |
| ◇ | 41-2 | 273-1200 | | 1 Hf and 0.11 Fe. | Large Crystal of ductile material. |
| △ | 54-23 | 272-889 | | α - Zr, hexagonal close packed; 2.4 Hf. | Annealed. |
| ▽ | 50-18 | 298-772 | | 2.4 Hf, 0.0180 Al, 0.055 N, 0.0050 > Ni, Cr each, 0.003 O, 0.0025 Mg, 0.0025 > Mn, Ca each, and 0.0020 Si. | Rolled, pickpunched to decrease orientation effect of rolling, and vacuum annealed 30 hrs at 550 C. |
| △ | 51-13 | 323-973 | | 97.406 Zr (by diff.), 2.4 Hf, 0.115 Fe, 0.022 Si, 0.008 Al, 0.005 Ti, 0.005 > Cr, Ni each, 0.003 Mg, 0.0025 > Mn, and 0.002 Ca. | |



SPECIFIC HEAT -- ZIRCONIUM + INDIUM

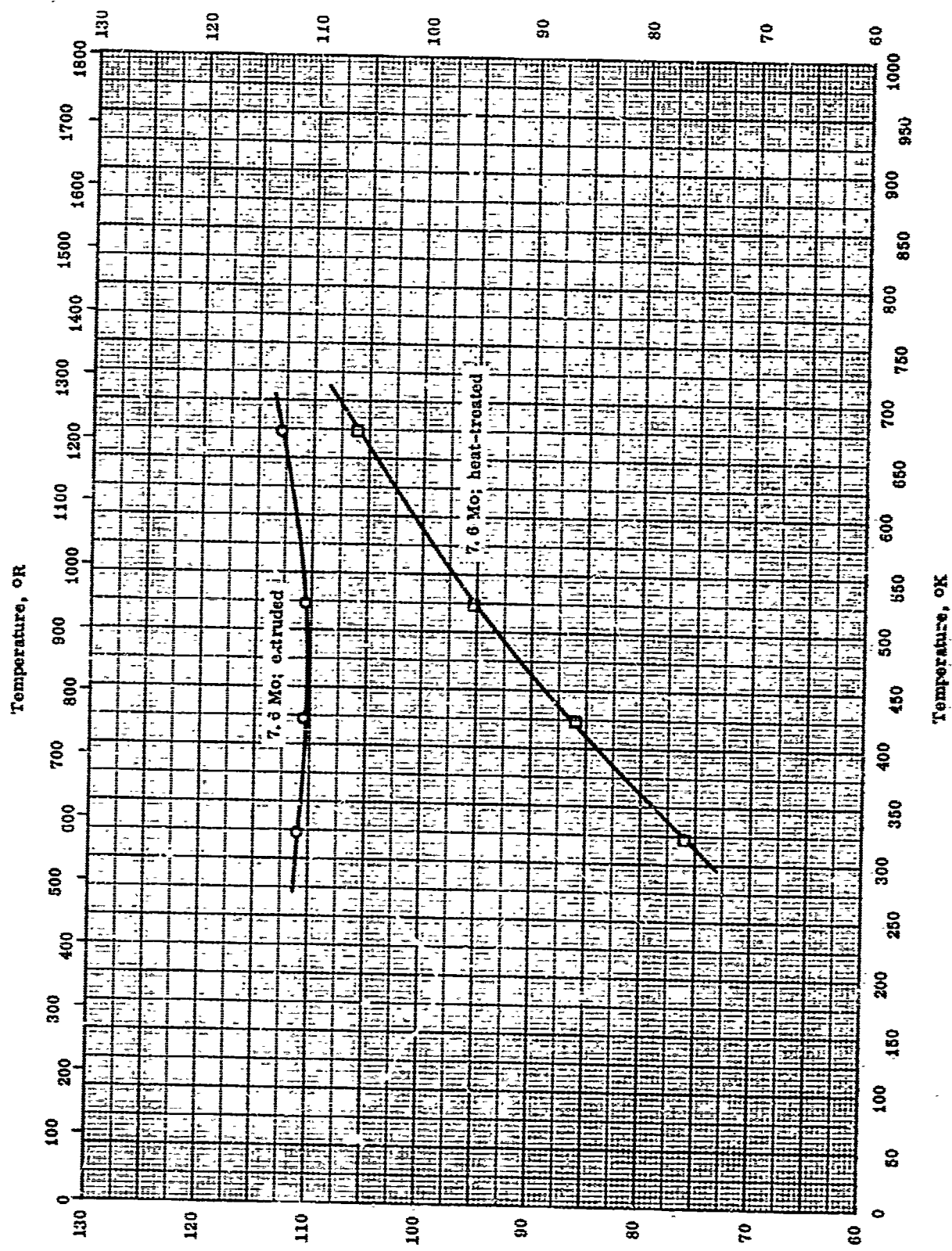
SPECIFIC HEAT -- ZIRCONIUM + INDIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 57-17 | 353-1178 | | 92.23 Zr, 7.77 In, 0.021 Fe, 0.016 O ₂ , 0.0067 C, 0.003 N ₂ , and 0.00051 H. [Author's design.; Run 54] | Arc melted; homogenized 14 days at 1300 C in vacuum. |
| □ | 57-17 | 353-1153 | | Same composition as above. [Author's design.; Run 55] | Same as above. |
| △ | 57-17 | 343-1173 | | Same composition as above. [Author's design.; Run 56] | Same as above. |
| ◇ | 57-17 | 333-1013 | | Same composition as above. [Author's design.; Run 58] | Same as above. |
| ▽ | 57-17 | 333-1133 | | Same composition as above. [Author's design.; Run 59] | Same as above. |

Electrical Resistivity, ohm cm x 10⁶

681



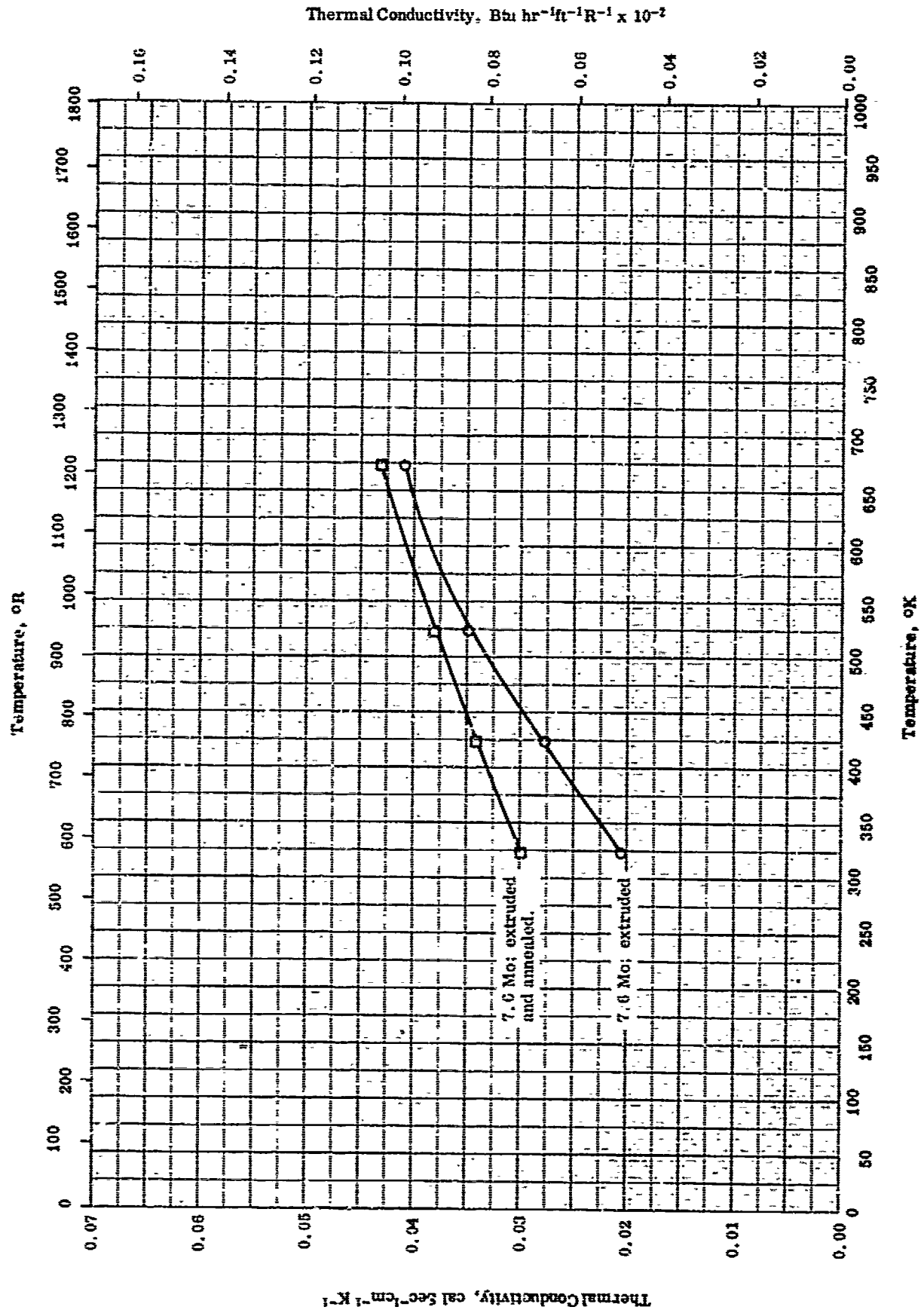
ELECTRICAL RESISTIVITY -- ZIRCONIUM + MOLYBDENUM

TPRC

ELECTRICAL RESISTIVITY -- ZIRCONIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|------------------------|
| ○ | 61-12 | 323-673 | | 7.6 Mo, 0.14 C, 0.10 O ₂ , and 0.015 Fe; prepared by graphite-melted Zr. | Extruded. |
| □ | 61-12 | 323-673 | | Same as above. | Heat-treated to 680 C. |



THERMAL CONDUCTIVITY -- ZIRCONIUM + MOLYBDENUM

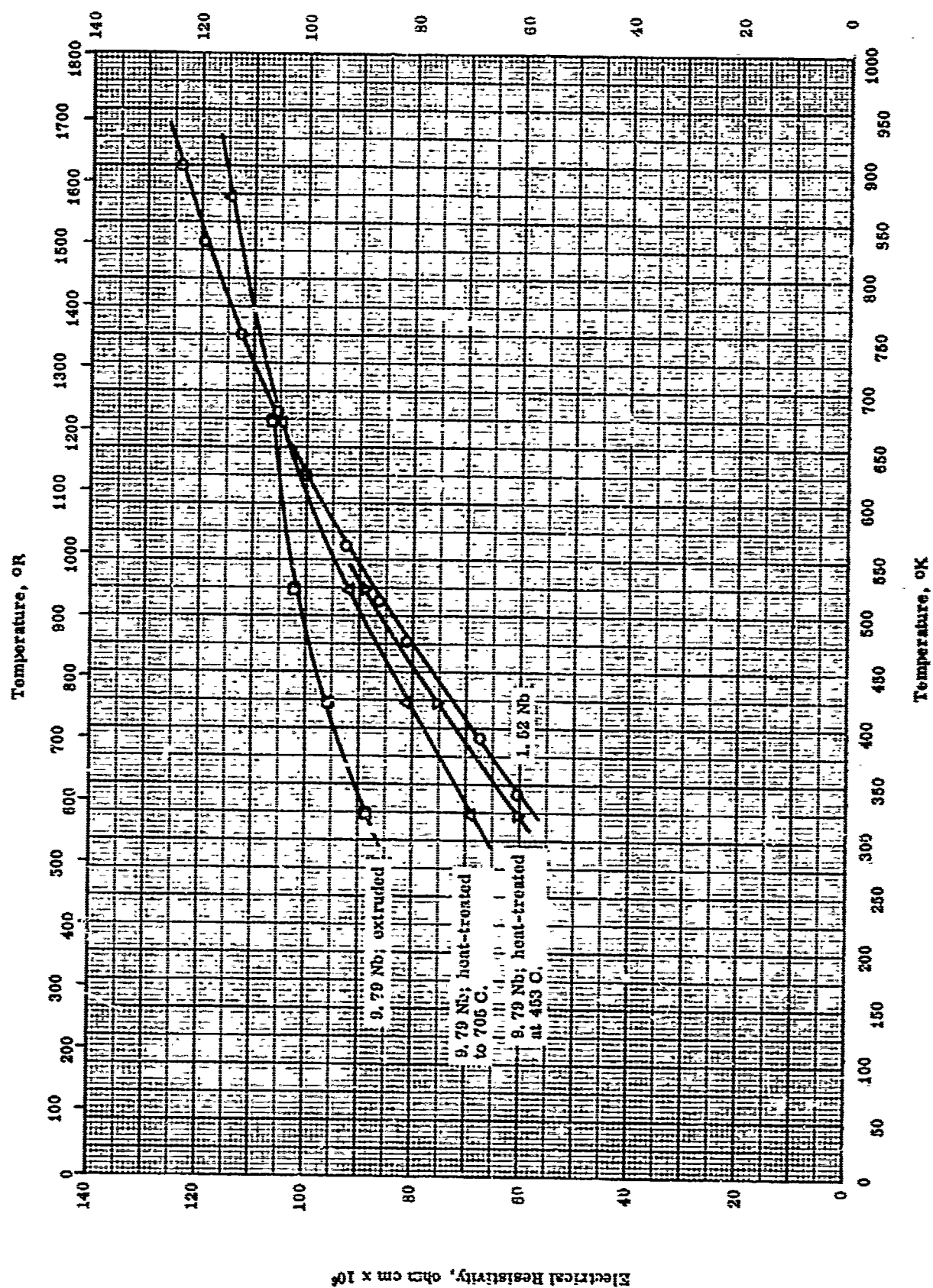
THERMAL CONDUCTIVITY --- ZIRCONIUM + MOLYBDENUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|-------------------------------------|
| ○ | 61-12 | 323-373 | | 7.0 Mo, 0.14 C, 0.10 O ₂ , and 0.015 Fe; graphite-molten Zr as raw material. | Extruded. |
| □ | 61-12 | 323-373 | | Same as above. | Extruded and heat-treated at 680 C. |

Electrical Resistivity, ohm cm x 10⁶

685

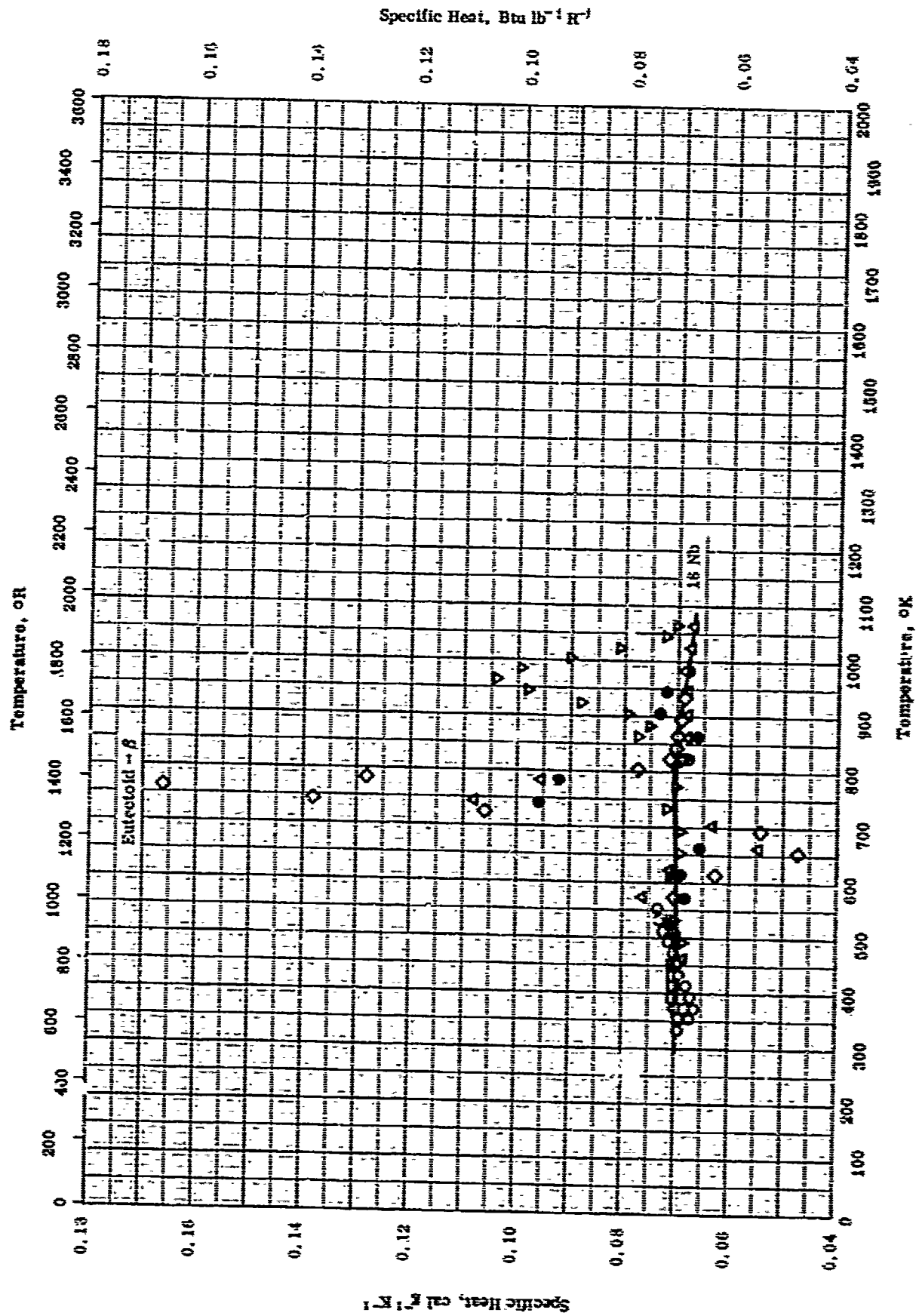


ELECTRICAL RESISTIVITY -- ZIRCONIUM + NIOBIUM

ELECTRICAL RESISTIVITY -- ZIRCONIUM + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|---|
| ○ | 57-7 | 343-900 | | 1. 52 Nb, 0. 14 Hf, and 0. 08 C. | Annealed 48 hrs at 600 C in vacuum and water quenched. |
| □ | 61-12 | 323-873 | 5 | 0. 70 Nb, 0. 10 C, and 0. 06 Fe; prepared from graphite-melted Zr. | Extruded. |
| △ | 61-12 | 323-873 | 5 | Same as above. | Heat-treated to 705 C. |
| ▽ | 61-12 | 323-823 | 5 | Same as above. | Heat-treated at 453 C. |

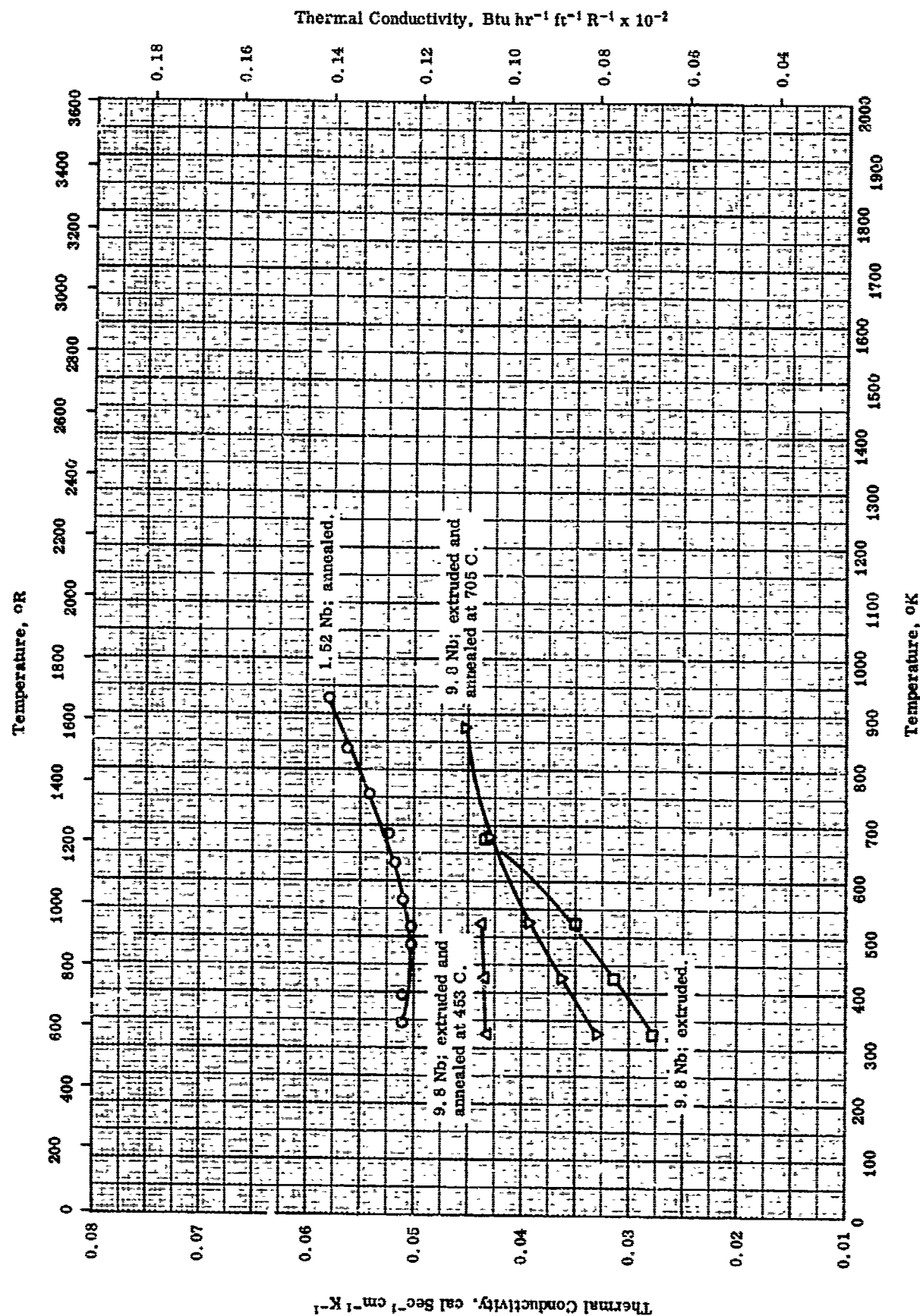


SPECIFIC HEAT -- ZIRCONIUM + NIOBIUM

SPECIFIC HEAT -- ZIRCONIUM + NIOBIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specification | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ○ | 57-17 | 333-553 | | Eutectoid composition; 82.5 Zr and 17.5 Nb. [Author's design.: Run 67] | Arc melted; cut into pieces and remelted twice. |
| □ | 57-17 | 333-553 | | Same as above. [Author's design.: Run 68] | Same as above. |
| △ | 57-17 | 343-1063 | | Same as above. [Author's design.: Run 69] | Same as above; heating rate during test at 200 C in 1 C min ⁻¹ . |
| ◇ | 57-17 | 373-933 | | Same as above. [Author's design.: Run 70] | Same as above; cooled in the calorimeter to room temperature from temperature of Run 69. |
| ▽ | 57-17 | 333-1063 | | Same as above. [Author's design.: Run 77] | Same as above; annealed two weeks at 600 C under rarefied argon. |
| ● | 57-17 | 373-983 | | Same as above. [Author's design.: Run 79] | Same as above; cooled to room temperature in the calorimeter from temperature of Run 77. |



THERMAL CONDUCTIVITY -- ZIRCONIUM + NIOBIUM

THERMAL CONDUCTIVITY -- ZIRCONIUM + NIOBIUM

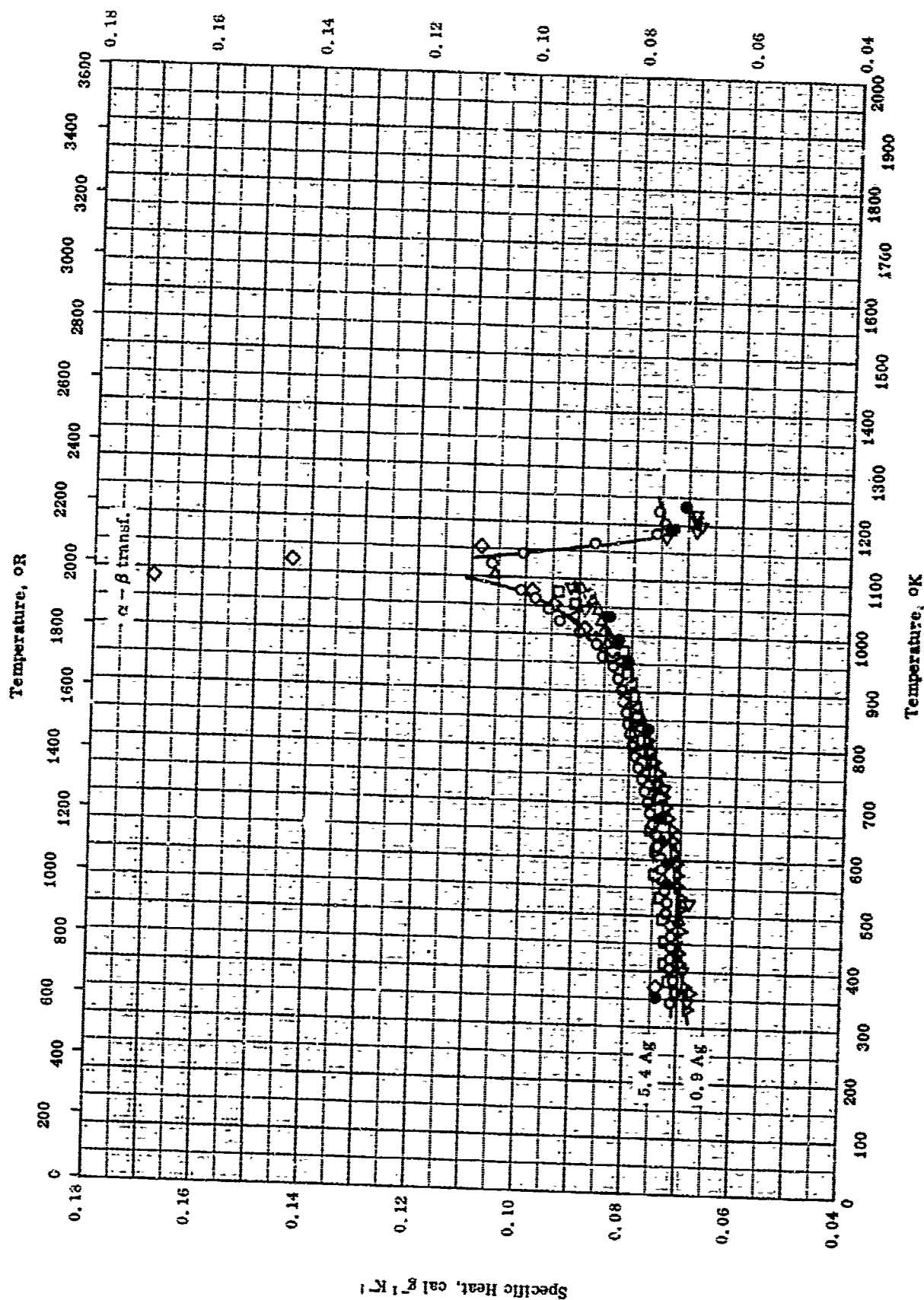
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|---|--|
| O | 57-7 | 342-328 | | 1.52 Nb, 0.14 Hf, and 0.08 C. | Annealed 48 hrs at 600 C in vacuum and water quenched. |
| □ | 61-12 | 323-673 | | 9.79 Nb, 0.19 C, and 0.06 Fe; graphite-molten Zr as raw material. | Extruded. |
| △ | 61-12 | 323-523 | | Same as above. | Extruded and heat-treated at 453 C. |
| ▽ | 61-12 | 323-873 | | Same as above. | Extruded and heat-treated at 705 C. |

TPRC

Specific Heat, Btu lb⁻¹ R⁻¹

691



SPECIFIC HEAT -- ZIRCONIUM + SILVER

TPRC

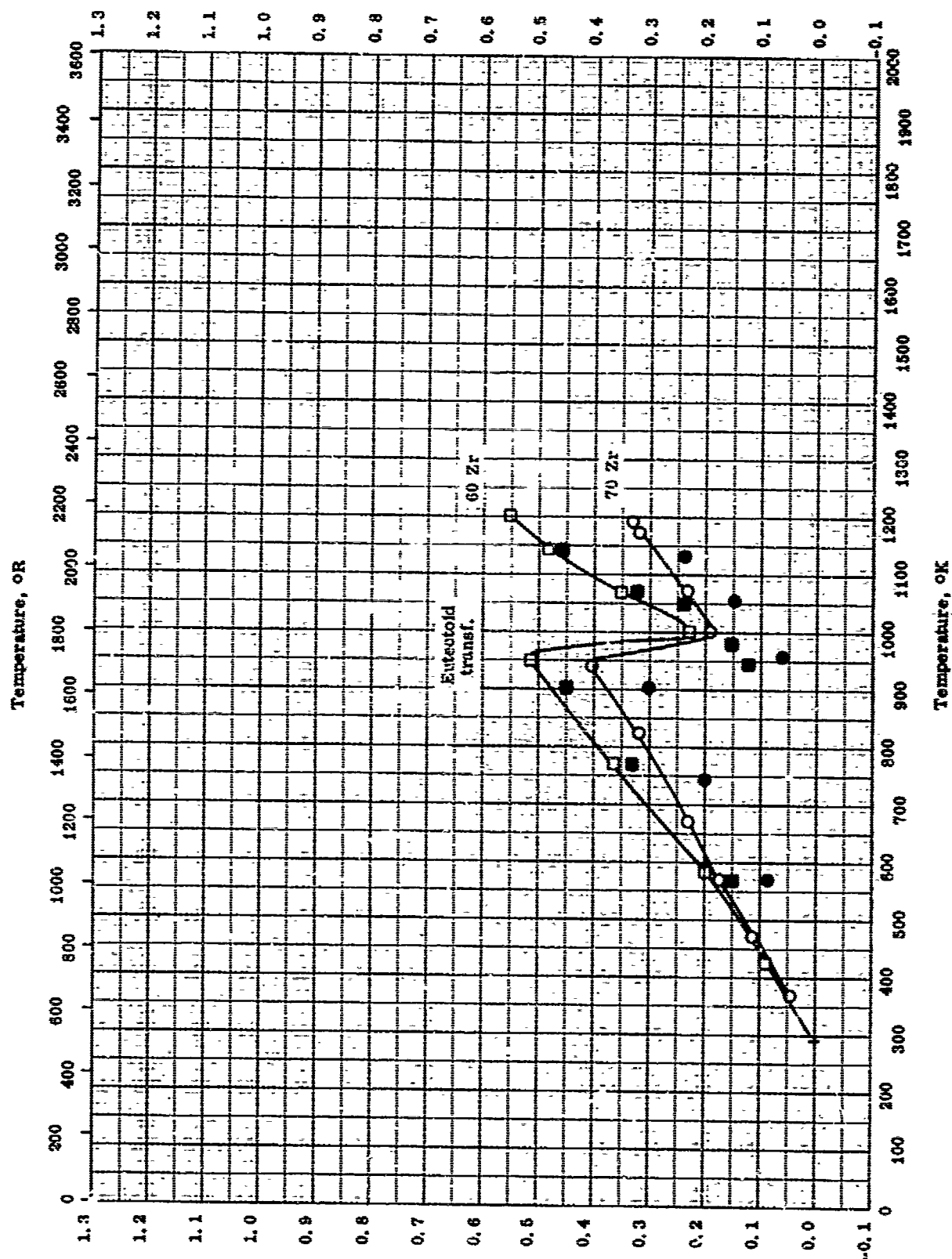
SPECIFIC HEAT -- ZIRCONIUM + SILVER

REFERENCE INFORMATION

| Sym Bol | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|--|
| ○ | 57-17 | 343-1223 | | 5.37 Ag, 0.028 Fe, 0.022 O ₂ , 0.0130 C, 0.0020 Cu, 0.0011 H ₂ , and 0.00049 N ₂ . [Author's design.: Run 32] | Arc melted; homogenized 14 days at 1300 C under 0.01 μ Hg vacuum. |
| □ | 57-17 | 383-1078 | | Same composition as above. [Author's design.: Run 33] | Same as above. |
| △ | 57-17 | 633-1033 | | Same composition as above. [Author's design.: Run 36] | Same as above. |
| ◇ | 57-17 | 373-1153 | | Same composition as above. [Author's design.: Run 37] | Same as above. |
| ▽ | 57-17 | 333-873 | | 0.881 Ag, 0.036 Fe, 0.015 O ₂ , 0.014 C, 0.004 Cu, 0.0008 N ₂ , 0.00044 H ₂ . [Author's design.: Run 13] | Arc melted; homogenized 14 days at 1300 C under 0.01 μ Hg vacuum. |
| △ | 57-17 | 373-1103 | | Same composition as above. [Author's design.: Run 14] | Same as above. |
| ▽ | 57-17 | 343-923 | | Same composition as above. [Author's design.: Run 15] | Same as above. |
| ● | 57-17 | 353-1213 | | Same composition as above. [Author's design.: Run 50] | Same as above. |

Thermal Linear Expansion, percent

693



THERMAL LINEAR EXPANSION -- ZIRCONIUM + THORIUM
(60 ± Zr ± 70)

TPRC

THERMAL LINEAR EXPANSION -- ZIRCONIUM + THORIUM
(60 ≤ Zr ≤ 70)

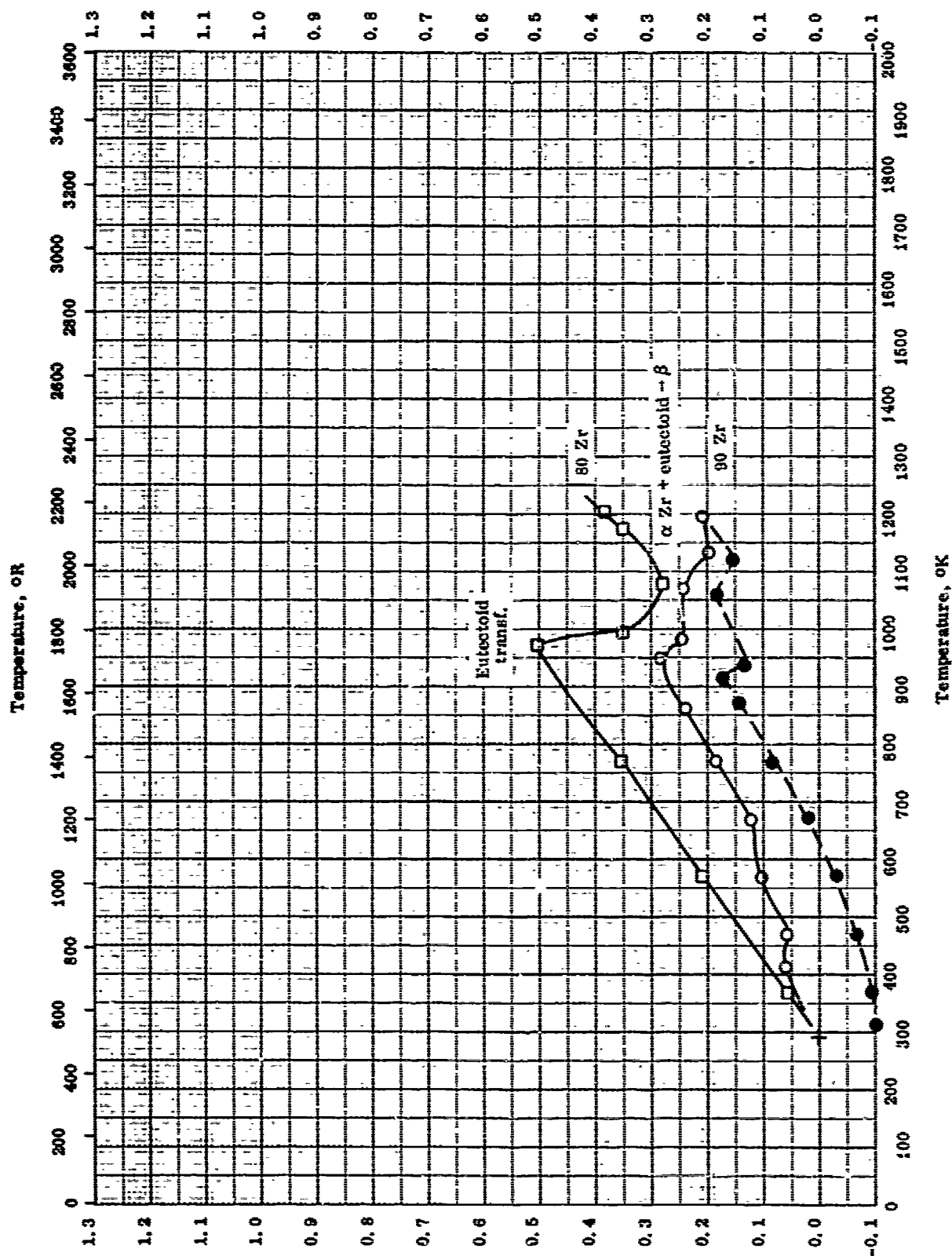
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|----------|
| ○ | 52-23 | 293-1193 | | 70 Zr and 30 Th. | Heating. |
| ● | 52-23 | 573-1193 | | Same as above. | Cooling. |
| □ | 52-23 | 293-1203 | | 60 Zr and 40 Th. | Heating. |
| ■ | 52-23 | 571-1203 | | Same as above. | Cooling. |

TPRC

Thermal Linear Expansion, percent

695



THERMAL LINEAR EXPANSION -- ZIRCONIUM + THORIUM
(80 ± Zr ± 90)

TPRC

THERMAL LINEAR EXPANSION --- ZIRCONIUM + THORIUM
(80 \pm Zr \pm 90)

REFERENCE INFORMATION

| Sym Sol | Ref. | Temp. Range °K | Opt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|-----------------------|----------|
| ○ | 52-23 | 293-1198 | | 90 Zr and 10 Th. | Heating. |
| ● | 52-23 | 316-1198 | | Same as above. | Cooling. |
| □ | 52-23 | 293-1203 | | 80 Zr and 20 Th. | |

PROPERTIES OF ZIRCONIUM + TIN

REPORTED VALUES

| Density: | g cm^{-3} | lb ft^{-3} |
|-----------|--------------------|---------------------|
| ○ 1.36 Sn | 6.4789 | 404.46 |
| □ 1.40 Sn | 6.5399 | 408.27 |
| △ 1.46 Sn | 6.4880 | 405.03 |
| ▽ 1.54 Sn | 6.5164 | 406.81 |
| ◇ 1.58 Sn | 6.4789 | 405.66 |

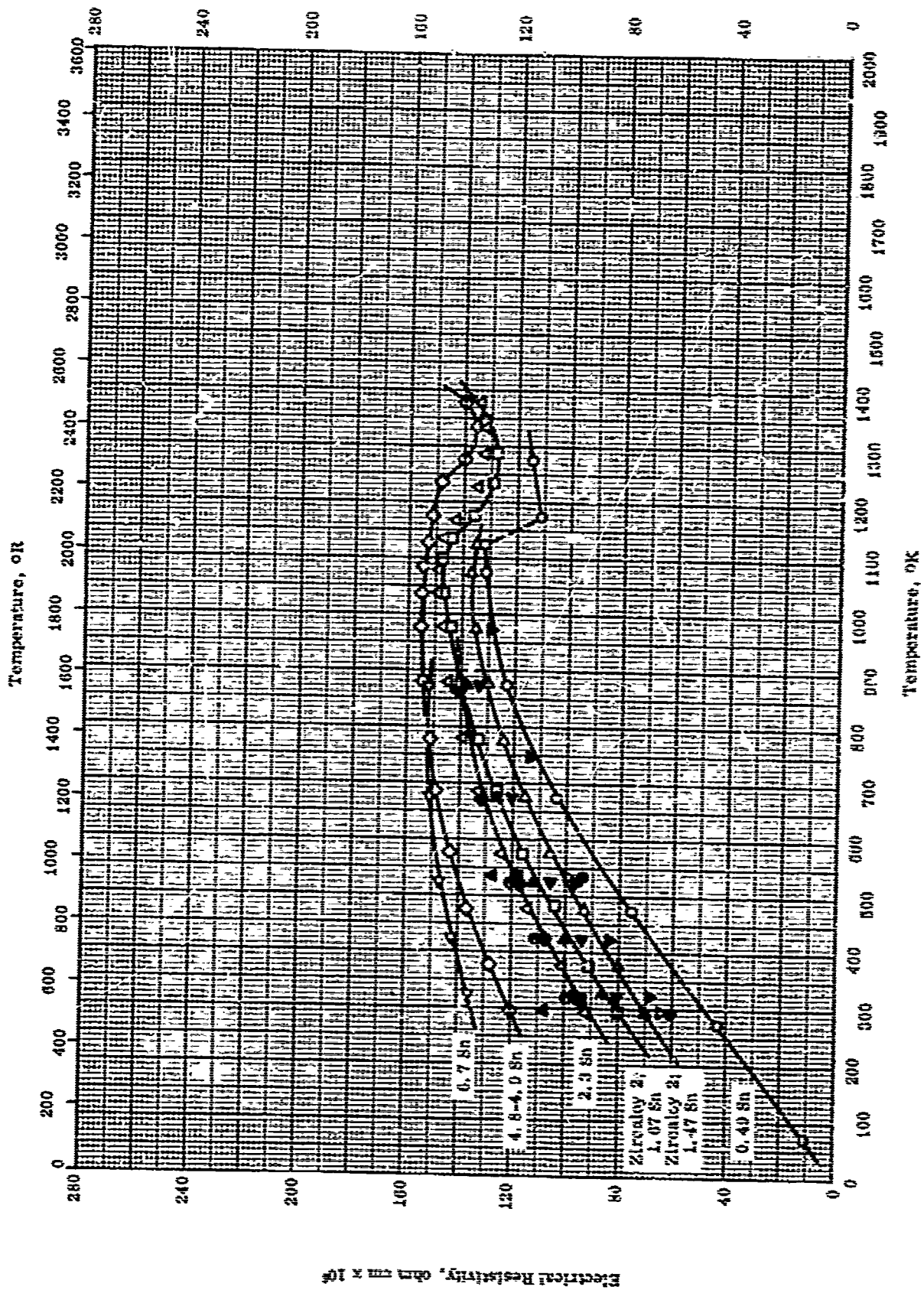
PROPERTIES OF ZIRCONIUM + TIN

REFERENCE INFORMATION

| Sym bol | Hc' | Temp. Range, °K | Repl. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|-----------------------|---|
| ○ | 57-38 | 298 | | 1.30 Sn. | Alloy made by two consumable electrode melts in sequence in arc furnace with 116 atm and extruded repeatedly; average value of 2-4 test each from weight and volume by CCl_4 displacement. |
| □ | 57-38 | 298 | | 1.40 Sn. | Same as above. |
| △ | 57-38 | 298 | | 1.40 Sn. | Same as above. |
| ▽ | 57-38 | 298 | | 1.54 Sn. | Same as above. |
| ◇ | 57-38 | 298 | | 1.68 Sn. | Same as above. |

Electrical Resistivity, ohm cm $\times 10^6$

595



ELECTRICAL RESISTIVITY -- ZIRCONIUM + TIN

ELECTRICAL RESISTIVITY -- ZIRCONIUM + TIN

REFERENCIAL INFORMATION

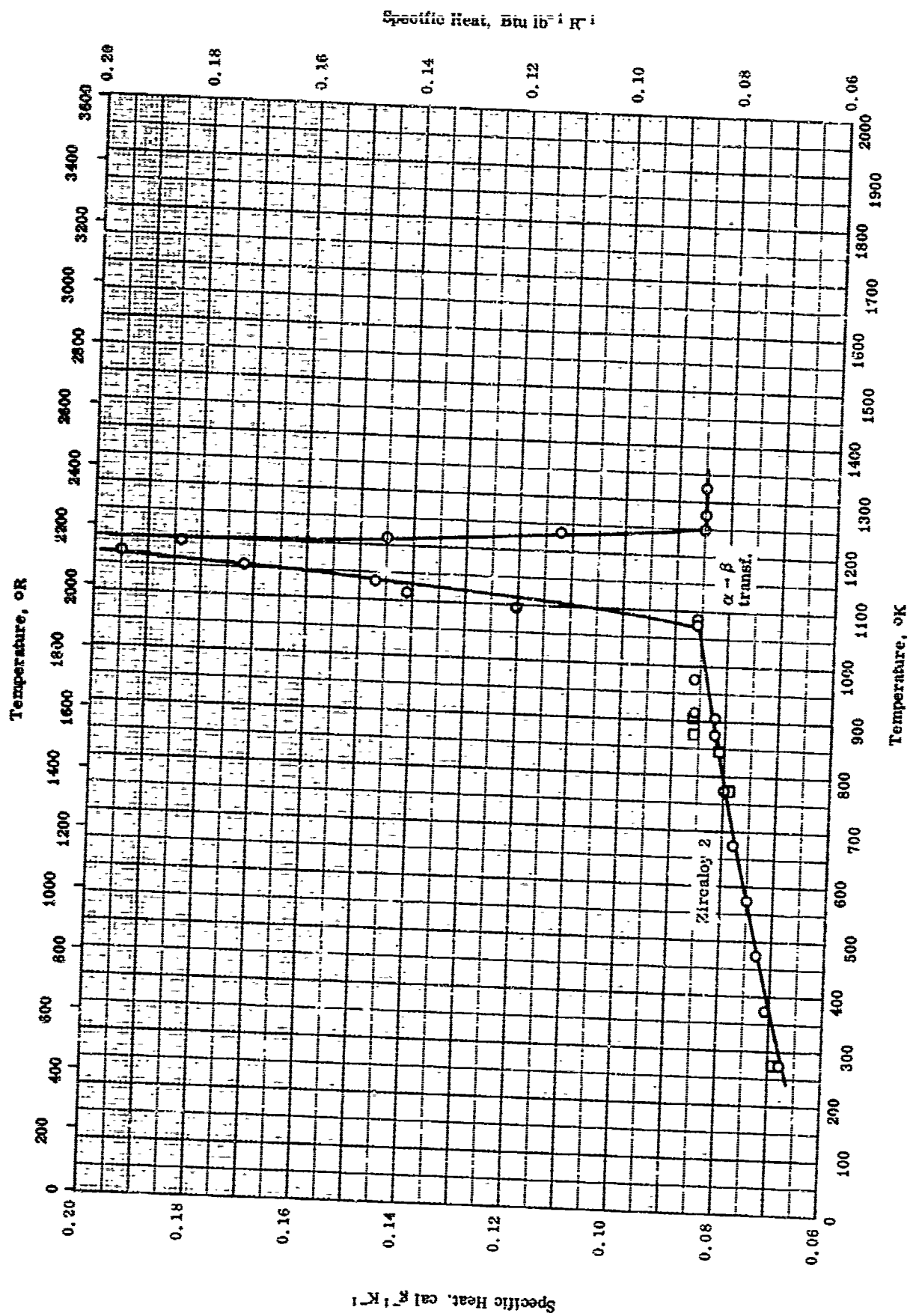
| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|--|
| ○ | 57-26 | 73-1273 | | 0.49 Sn, 0.08 O ₂ , 0.05 Hf, 0.02 Fe, and 0.01 C. | |
| □ | 54-14 | 293-1323 | ± 2 | Zircaloy 2; 1.67 Sn, 0.20 Fe, 0.10-0.11 Cr, 0.05 Ni, and 0.17-0.20 C. | Melted in vacuum induction furnace; forged at 900 C and rolled at 815-840 C. |
| △ | 54-14 | 293-1323 | ± 2 | Sponge Zirconium; 2.58-2.65 Sn, 0.16-0.21 C, and 0.009 N. | Melted in vacuum induction furnace; forged at 900-925 C and rolled at 815-840 C. |
| ◇ | 54-14 | 293-1323 | ± 2 | Sponge Zirconium; 4.60-4.93 Sn, 0.17-0.25 C, and 0.009 N. | Melted in vacuum induction furnace; forged at 980-1000 C and rolled at 840-870 C. |
| ▽ | 51-7 | 298-533 | ± 1 | 1 Sn; actual: 1.00 Sn, 0.155 Fe, 0.022 Hf, 0.013 C, 0.009 Al, 0.005 N, and 0.001 Ti. | |
| ● | 51-7 | 298-533 | ± 1 | 1.03 Sn, 0.019 C, and 0.006 N. | |
| ■ | 51-7 | 298-533 | ± 1 | 3 Sn; actual 2.97-3.02 Sn, 0.04-0.185 Fe, 0.03-0.085 Hf, and 0.1 > total of C, Ti, Al, and N. | Mean values for 4 samples of various composition and treatments within a spread of ± 2%. |
| ▲ | 51-7 | 298-533 | ± 1 | 5 Sn; actual 4.85 Sn, 0.12 C, and 0.1 > total of Fe, Hf, Ti, Al, N, and Ni. | |
| △ | 61-21 | 293-1123 | | Zircaloy 2; 1.47 Sn, 0.125 Fe, 0.086 Cr, and 0.055 Ni. | |
| ▼ | 61-12 | 323-873 | 5 | 0.84 Sn, 0.1 C, and 0.04 Fe; prepared by graphite-melted Zr. | Extruded. |
| ◀ | 61-12 | 323-873 | 5 | 1.37 Sn, 0.14 Fe, 0.13 C, 0.098 O ₂ , 0.09 Cr, 0.07 Ni, and 0.608 Ca; prepared by graphite-melted Zr. | Extruded. |
| ▶ | 61-12 | 323-873 | 5 | 1.65 Sn, 0.14 O ₂ , 0.13 C, and 0.05 Fe; prepared by graphite-melted Zr. | Extruded. |

(Continued onto next page)

ELECTRICAL RESISTIVITY -- ZIRCONIUM + TIN (continued)

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range, °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|--------------------|------------------|---|-----------|
| ◆ | 61-12 | 323-873 | 5 | 2.3 Sn, 0.14 O ₂ , 0.10 C, 0.02 Fe, and 0.007 N ₂ ; prepared by graphite-melted Zr. | Extruded. |
| ○ | 61-12 | 323-873 | 5 | 2.38 Sn, 0.14 C, 0.14 O ₂ , 0.12 Fe, ≈0.1 Al, and ≈0.05 Nb; prepared by graphite-melted Zr. | Extruded. |
| ◁ | 61-12 | 323-873 | 5 | 6.7 Sn, 0.10 C, 0.10 O ₂ , 0.05 Fe, and 0.007 N ₂ ; prepared by graphite-melted Zr. | Extruded. |

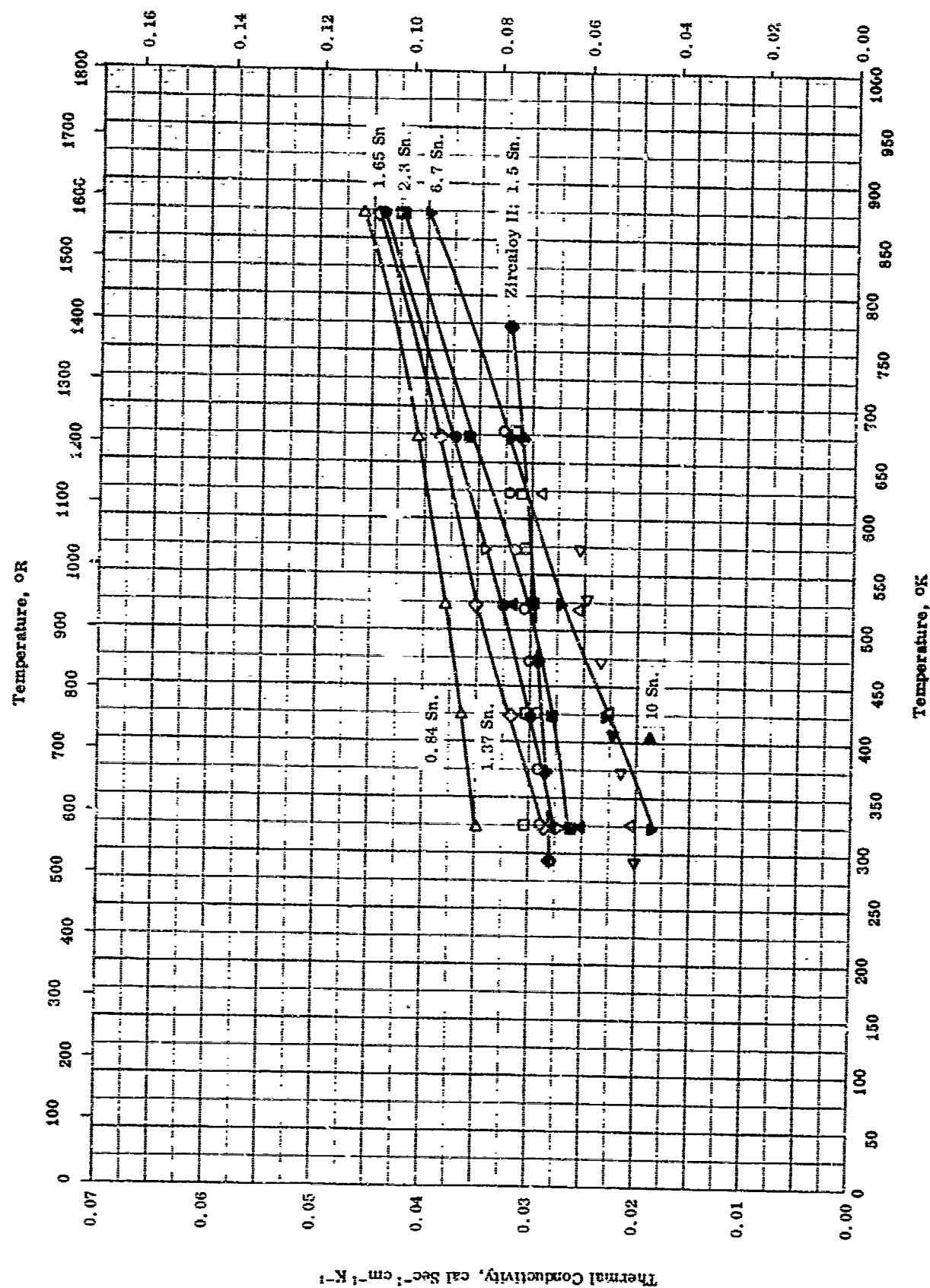


SPECIFIC HEAT -- ZIRCONIUM + TIN

SPECIFIC HEAT - - ZIRCONIUM + TIN

REFERENCE INFORMATION

| Sym Bdl | Ref. | Temp. Range °C | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---------|
| ○ | 63-14 | 273-1323 | | Zircaloy 2; nominal composition: 1.5 Sn, 0.15 Fe, 0.10 Cr, and 0.05 Ni. | |
| □ | 63-14 | 273-1323 | | Low-nickel Zircaloy 2 (Zircaloy 4); nominal composition: 1.32 Sn, 0.152 Fe, 0.099 Cr, and 0.001 Ni. | |



THERMAL CONDUCTIVITY --- ZIRCONIUM + TIN

TPRC

THERMAL CONDUCTIVITY -- ZIRCONIUM + TIN

REFERENCE INFORMATION

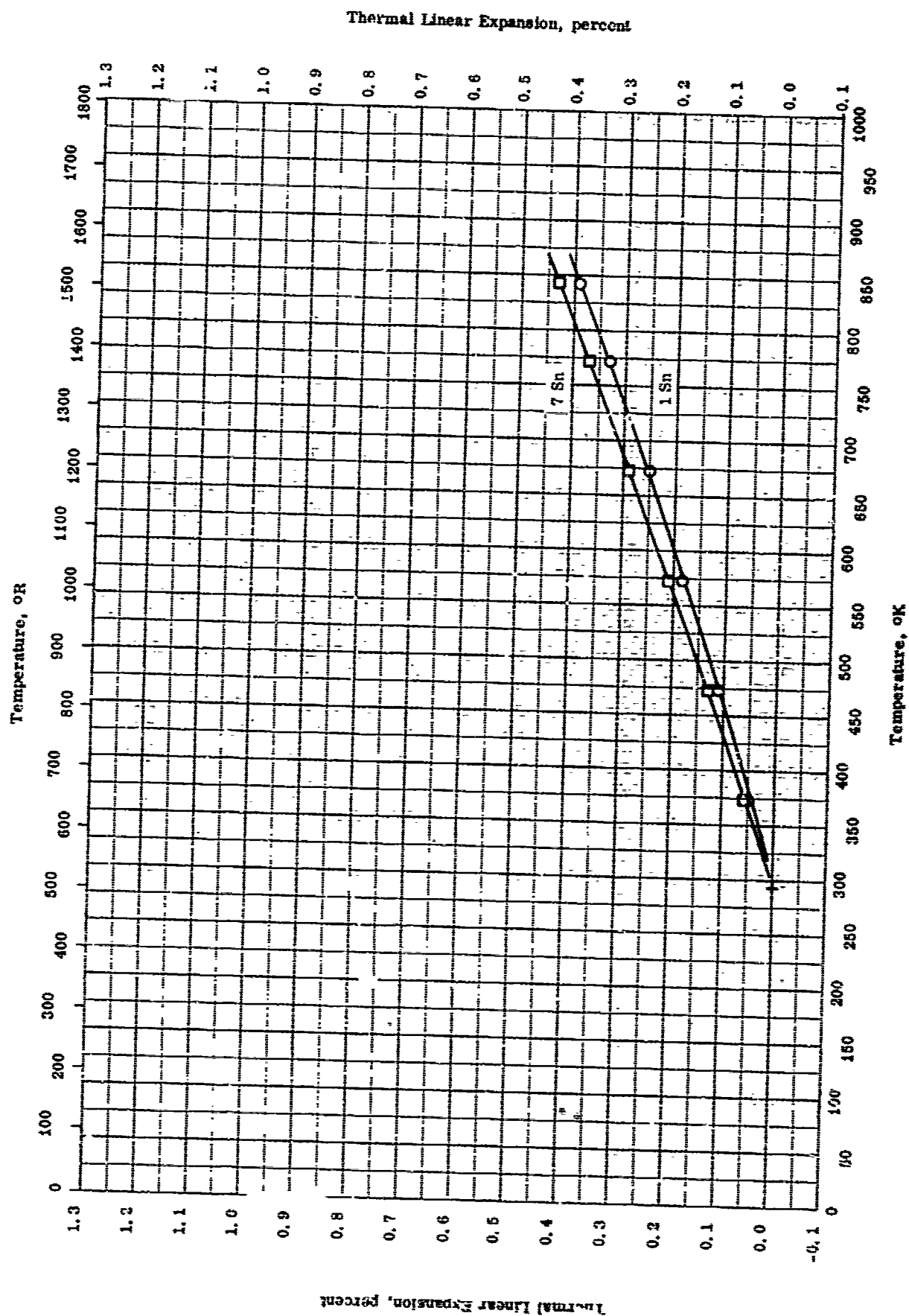
| Sym Eq | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-------|-------------------|------------------|--|--|
| ○ | 53-9 | 323-673 | | 2.3 Sn, 0.002 N ₂ ; prepared from sponge Zr. | Are-melted, forged, and rolled at 1600 F. |
| □ | 53-9 | 323-673 | | 2.51 Sn, 0.002 N ₂ ; prepared from WAPD Grade 1 crystal Zr and C. P. Sn. | Are-melted and forged at 1700 F. |
| △ | 53-9 | 323-673 | | 7.0 Sn; prepared from Foote Grade 1 crystal bar and C. P. Sn. | Are-melted. |
| ▽ | 55-7 | 323-873 | | 3.0 Sn. | Double melted. |
| ◁ | 51-7 | 323-573 | ± 3 | 95 Zr and 5 Sn; nominal composition. | Induction melted in graphite from low Hf sponge and forged at 1800 F in air. |
| ▼ | 56-11 | 407 | | 7.0 Sn. | |
| ▲ | 56-11 | 404 | | 10.0 Sn. | Extruded. |
| △ | 61-12 | 323-873 | | 0.84 Sn, 0.10 C, and 0.04 Fe; graphite-melted Zr as raw material. | Extruded. |
| ◇ | 61-12 | 323-873 | | 1.37 Sn, 0.14 Fe, 0.13 C, 0.098 O ₂ , 0.09 Cr, 0.07 Ni, and 0.008 Ca; graphite-melted Zr as raw material. | Extruded. |
| ● | 61-12 | 323-873 | | 1.65 Sn, 0.14 O ₂ , 0.10 C, 0.02 Fe, and 0.007 N ₂ ; graphite-melted Zr as raw material. | Extruded. |
| ■ | 61-12 | 323-873 | | 2.3 Sn, 0.14 O ₂ , 0.10 C, 0.02 Fe, and 0.007 N ₂ ; graphite-melted Zr as raw material. | Extruded. |
| ▲ | 61-12 | 323-873 | | 2.38 Sn, 0.14 C, 0.14 O ₂ , 0.12 Fe, ≈0.1 Al, and ≈0.05 Nb; graphite-melted Zr as raw material. | Extruded. |

(Continued onto next page)

THERMAL CONDUCTIVITY - ZIRCONIUM + TIN (Continued)

REFERENCE INFORMATION

| Sym- bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-------------|-------|-------------------|------------------|---|-----------|
| ▼ | 61-12 | 323-373 | | 6.7 Sn, 0.10 C, 0.10 O ₂ , 0.05 Fe, and 0.007 N ₂ ; graphite-melted Zr as raw material ² . | Extruded. |
| ◆ | 59-5 | 293-772 | | Zirconium II; 1.5 Sn, 0.15 Fe, 0.10 C ₂ , and 0.05 Ni. | |



THERMAL LINEAR EXPANSION -- ZIRCONIUM + TIN

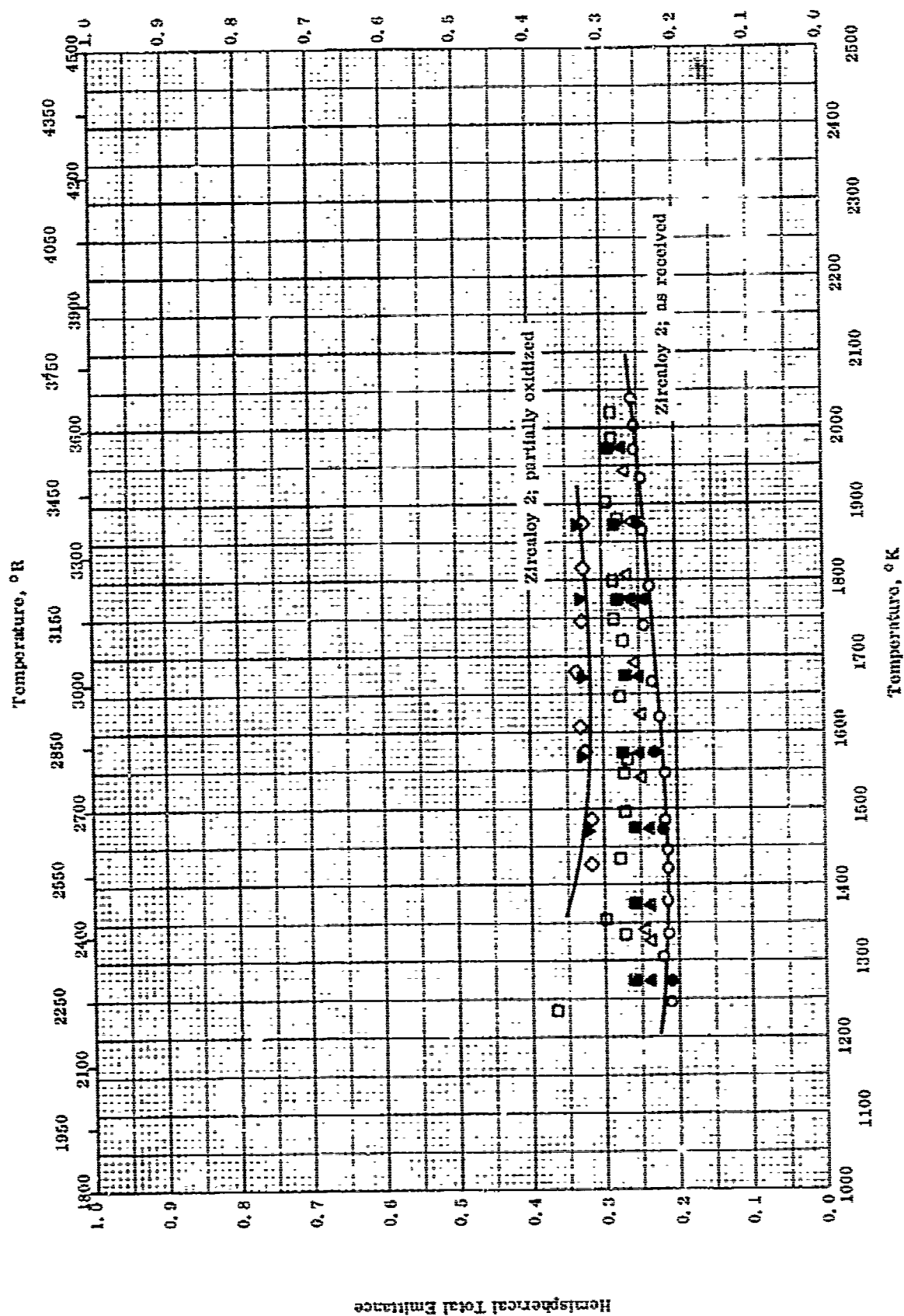
THERMAL LINEAR EXPANSION -- ZIRCONIUM + TIN

REFERENCE INFORMATION

| Sym col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|---|
| ○ | 62-21 | 103-843 | | 99 Zr, 1 Sn. | Heated in Argon at 25 C min ⁻¹ ; 325 mesh powders pressed at 75 tsi and sintered 10 hrs at 1270 C in vacuum. |
| □ | 52-21 | 303-843 | | 93 Zr, 7 Sn. | Same as above. |

Hemispherical Total Emittance

709



HEMISPHERICAL TOTAL EMITTANCE --- ZIRCONIUM + TIN

TPRC

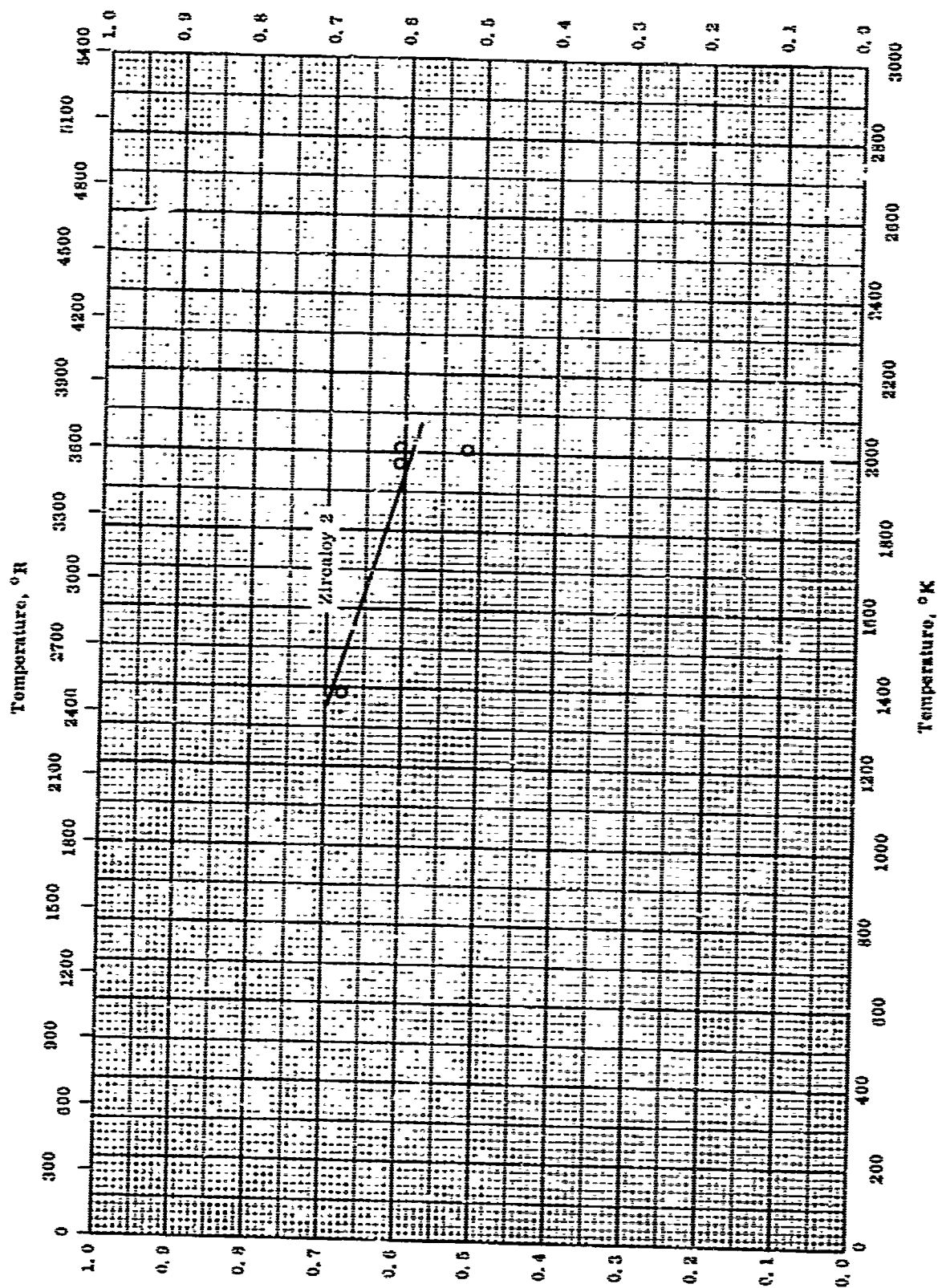
HEMISPHERICAL TOTAL EMITTANCE -- ZIRCONIUM + TIN

REFERENCE INFORMATION

| Sym Co | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|-----------|-------|-------------------|------------------|---|------------------------------------|
| ○ | 57-47 | 1246-2038 | ±3 | Zircaloy 2; 98.2 Zr, 1.5 Sn, 0.15 Fe, 0.10 Cr and 0.05 Ni. | As received; measured in vacuum. |
| △ | 57-47 | 1320-1941 | ±3 | Same as above. | 5 atomic % oxygen. |
| □ | 57-47 | 1230-2021 | ±3 | Same as above. | 10 atomic % oxygen. |
| ◇ | 57-47 | 1420-1873 | ±3 | Same as above. | 22 atomic % oxygen. |
| ● | 56-39 | 1273-1973 | | Zircaloy 2; nominal: 1.6 Sn, 0.15 Fe, 0.10 Cr, and 0.05 Ni. | As received. |
| ▲ | 56-39 | 1273-1973 | | Same as above. | Approximately 7.5 atomic % oxygen. |
| ■ | 56-39 | 1273-1973 | | Same as above. | Approximately 15 atomic % oxygen. |
| ▼ | 56-39 | 1473-1873 | | Same as above. | Approximately 30 atomic % oxygen. |

Normal Total Emittance

711



NORMAL TOTAL EMITTANCE -- ZIRCONIUM + TIN

Normal Total Emittance

TPRC

NORMAL TOTAL EMITTANCE -- ZIRCONIUM + TIN

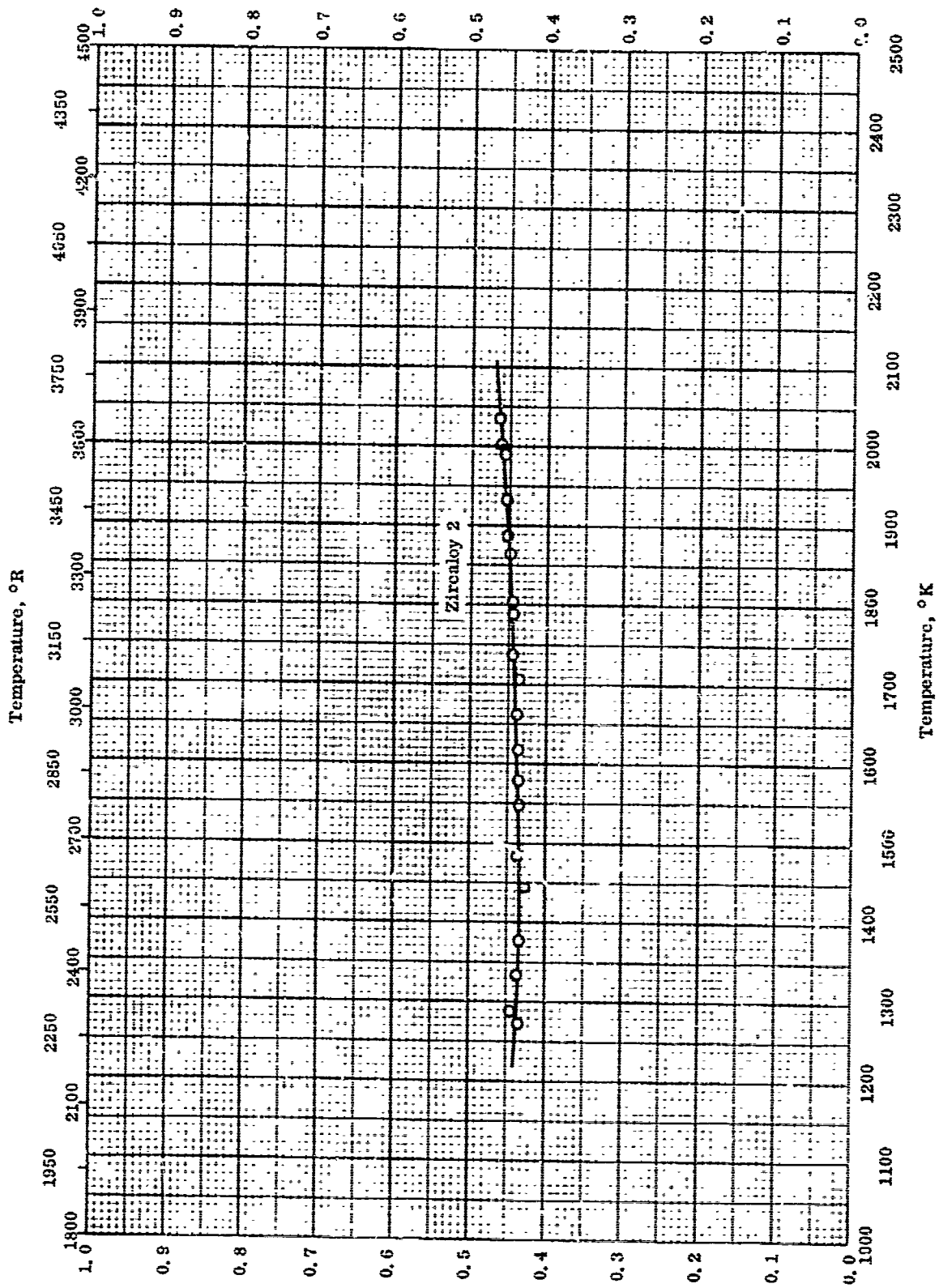
REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rpt. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|-----------------|---|-----------------------------------|
| O | 57-47 | 1385-1973 | | Zircaloy 2; 98.2 Zr, 1.5 Sn, 0.15 Fe, 0.10 Cr, and 0.05 Ni. | Liquid state; measured in vacuum. |

TPRC

Normal Spectral Emittance

715



Normal Spectral Emittance

TPRC

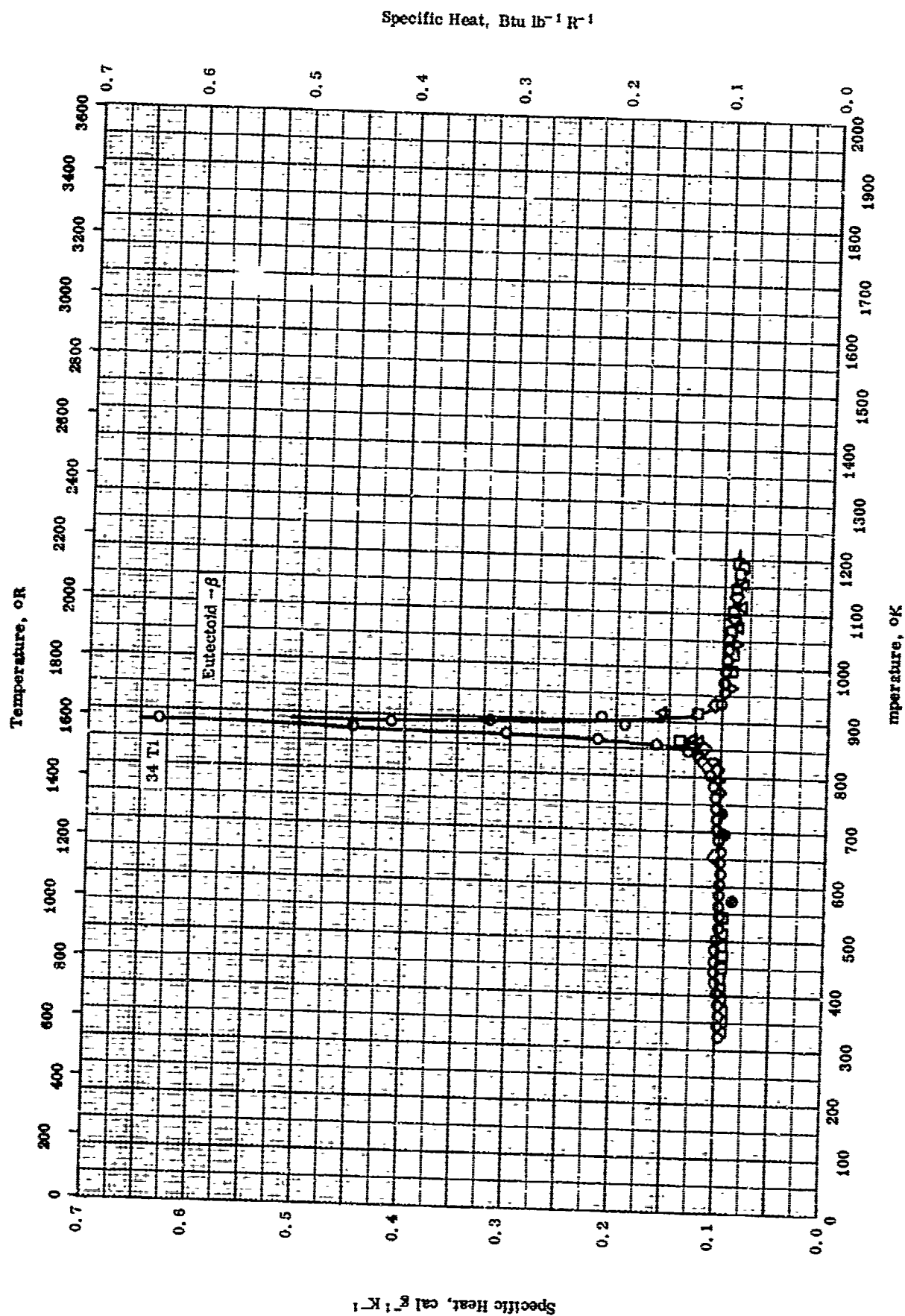
NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM + TiN

NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM + TIN

REFERENCE INFORMATION

| Sym bol | Ref. | Wavelength μ | Temp. °K Range | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|---------------------|-------------------|------------------|---|----------------------------------|
| O | 57-47 | 0.65 | 1273-2035 | ±5 | Zircaloy 2; 98.2 Zr, 1.5 Sn, 0.15 Fe and 0.10 Cr. | As received; measured in vacuum. |

TPRC



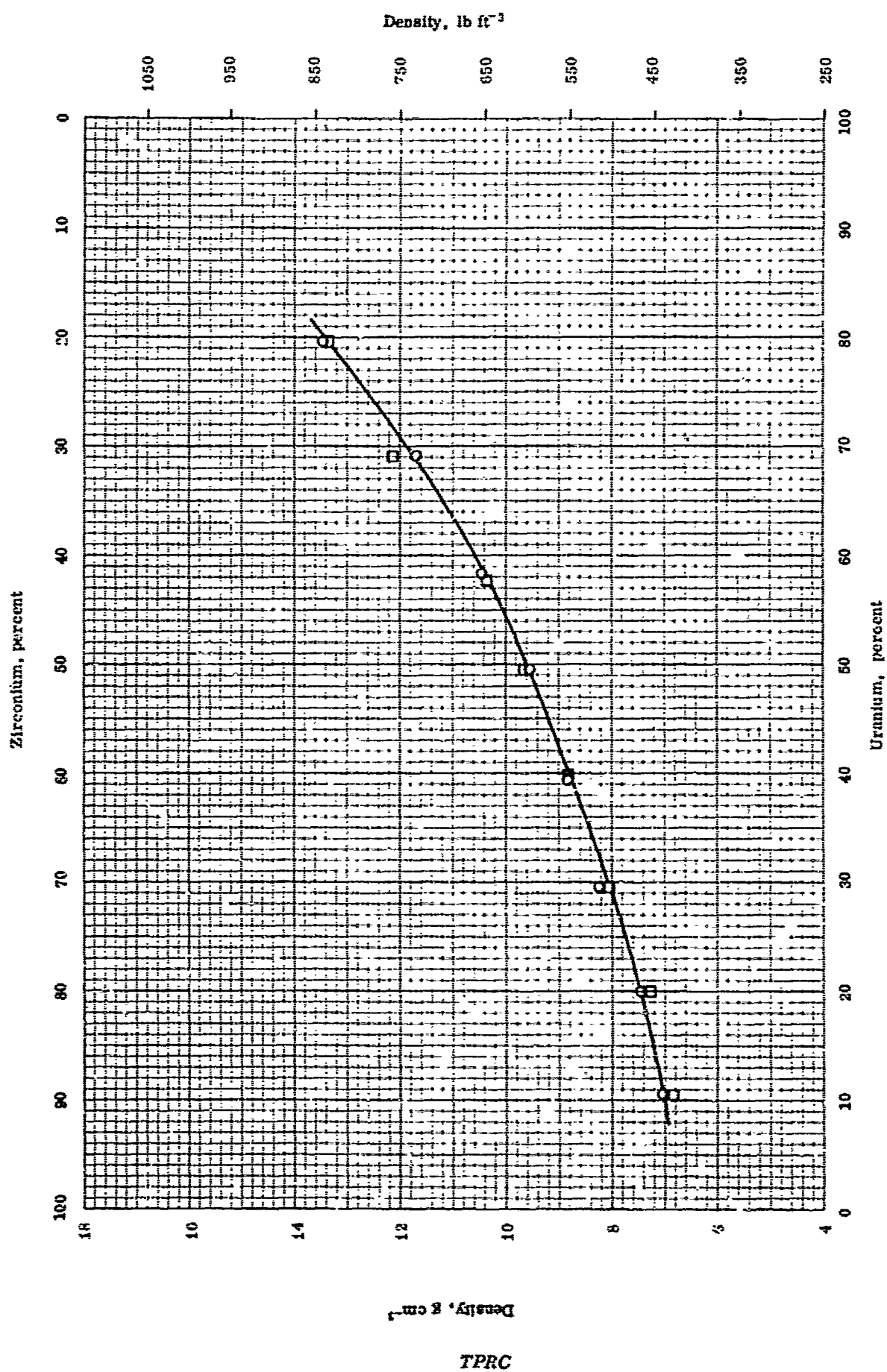
SPECIFIC HEAT -- ZIRCONIUM + TITANIUM

TPRC

SPECIFIC HEAT -- ZIRCONIUM + TITANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|--|---|
| ○ | 57-17 | 323-1053 | | Eutectoid composition; 65.6 Zr and 34.4 Ti. [Author's design.; Run 43] | Arc melted from iodide process Zr and Ti. |
| □ | 57-17 | 333-1183 | | Same composition as above. [Author's design.; Run 45] | Same as above. |
| △ | 57-17 | 403-1153 | | Same composition as above. [Author's design.; Run 46] | Same as above. |
| ◇ | 57-17 | 373-1133 | | Same composition as above. [Author's design.; Run 47] | Same as above. |
| ▽ | 57-17 | 353-1133 | | Same composition as above. [Author's design.; Run 49] | Same as above. |
| ● | 57-17 | 333-1055 | | Same composition as above. [Author's design.; Run 79] | Same as above; homogenized at 800 C for 2 hrs and water quenched. |



DENSITY -- ZIRCONIUM + URANIUM

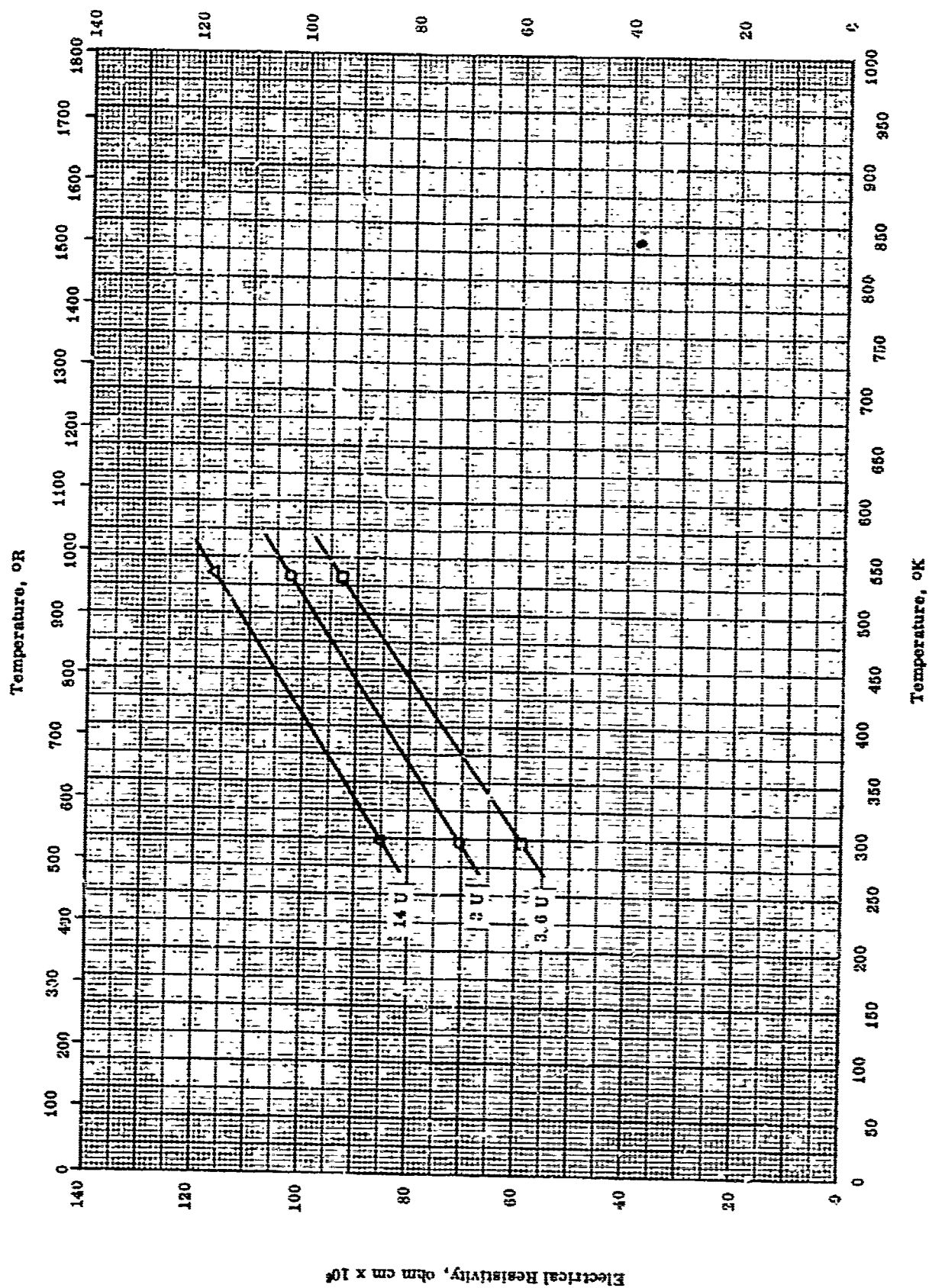
DENSITY -- ZIRCONIUM + URANIUM

REFERENCE INFORMATION

| Sym No. | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|-----------------------|--|
| ○ | 53-22 | 208 | | 10-80 U. | Heat - treated 1 hr at 800 C and water quenched. |
| □ | 53-22 | 298 | | 10-80 U. | Heat-treated 24 hrs at 575 C and furnace cooled. |

Electrical Resistivity, ohm cm $\times 10^6$

719

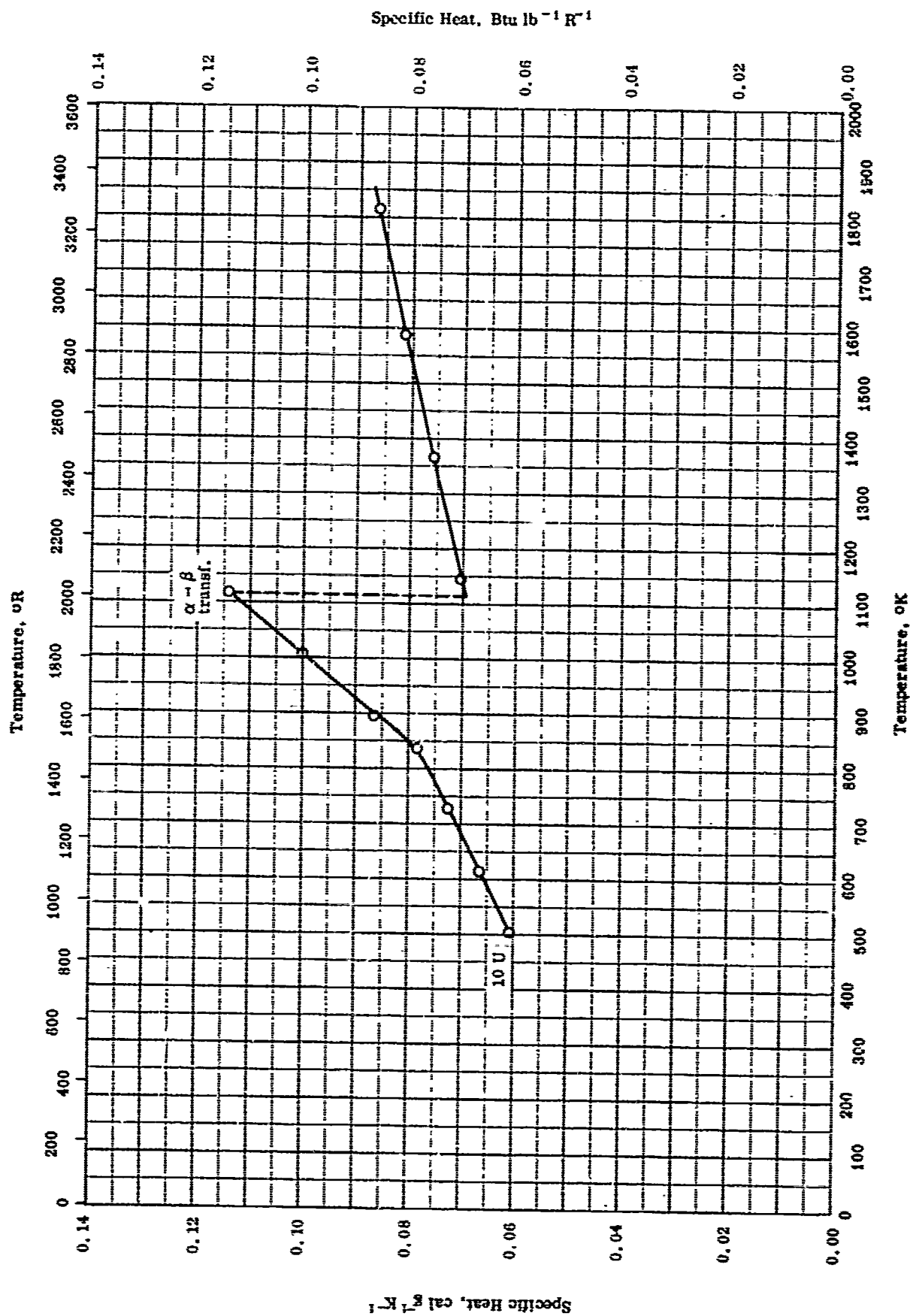


ELECTRICAL RESISTIVITY -- ZIRCONIUM + URANIUM

ELECTRICAL RESISTIVITY -- ZIRCONIUM + URANIUM

REFERENCE INFORMATION

| Sym Col | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-------------------------------|--|
| O | 51-7 | 298-533 | ± 1 | 3 U. | Low hafnium crystal bar; double arc melted, forged Δ 50 F, rolled at 1250 F, and annealed at 1450 F. |
| □ | 51-7 | 298-533 | ± 1 | 3, 61 U, 0.05 C, and 0.007 N. | |
| Δ | 61-7 | 298-533 | ± 1 | 14 U. | |

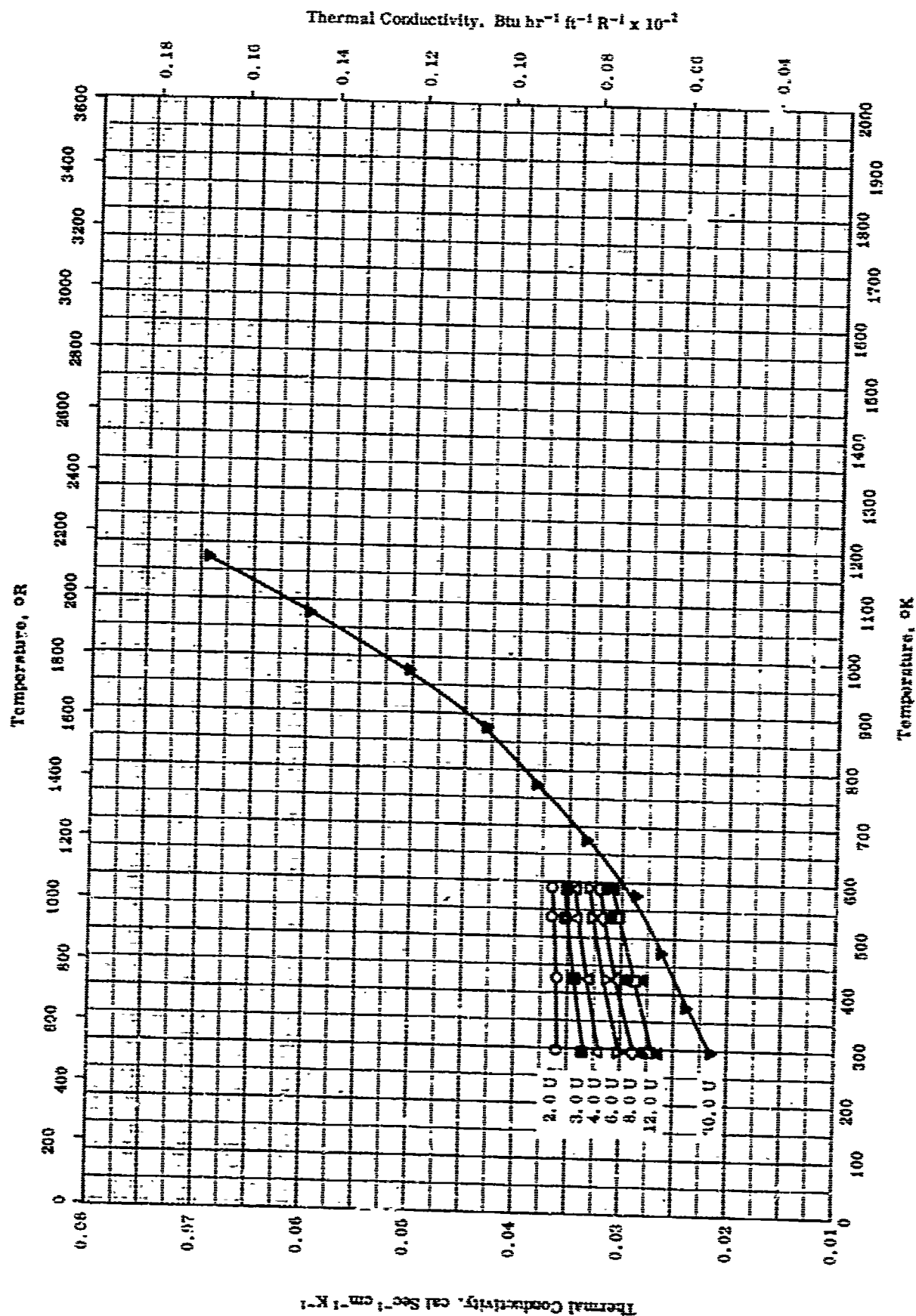


SPECIFIC HEAT -- ZIRCONIUM + URANIUM

SPECIFIC HEAT -- ZIRCONIUM + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|-------|-------------------|------------------|---|-------------------------|
| O | 63-12 | 422-1975 | ± 2.0 | 89.52 Zr and 10.48 U; density 430 lb ft ⁻³ . | Under argon atmosphere. |

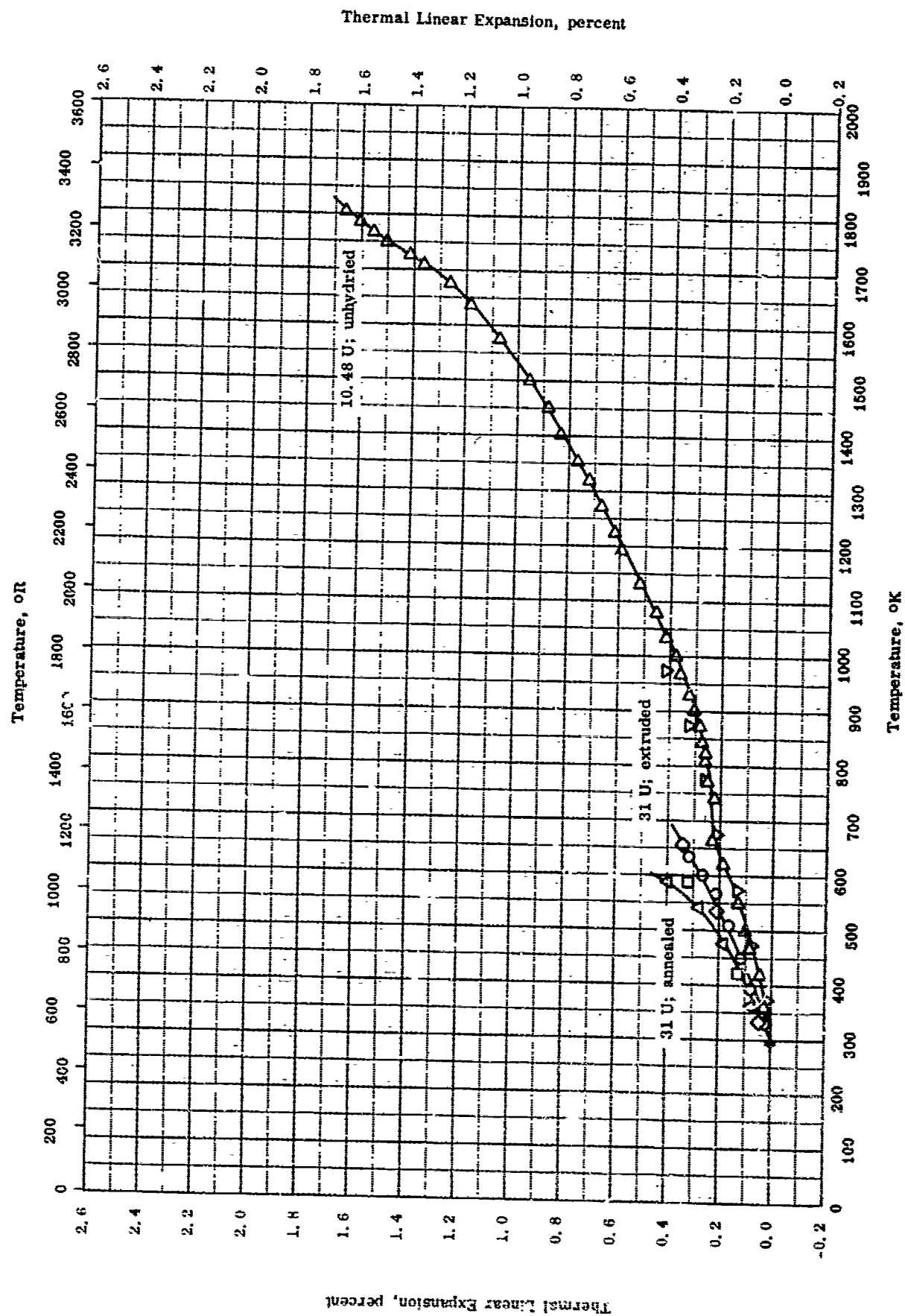


THERMAL CONDUCTIVITY -- ZIRCONIUM + URANIUM

REFERENCE INFORMATION

| Sym bol | Ref. | Temp. Range °K | Rept. Error % | Sample Specifications | Remarks |
|------------|------|-------------------|------------------|-----------------------|---------|
| ○ | 57-6 | 293-589 | | 2.0 U. | |
| ■ | 57-6 | 293-589 | | 3.0 U. | |
| △ | 57-6 | 293-589 | | 4.0 U. | |
| ▽ | 57-6 | 293-589 | | 6.0 U. | |
| ◇ | 57-6 | 293-589 | | 8.0 U. | |
| ● | 57-6 | 293-589 | | 10.0 U. | |
| □ | 57-6 | 293-589 | | 11.0 U. | |
| ▲ | 57-6 | 293-589 | | 14.0 U. | |
| ▼ | 54-6 | 293-1173 | | 30.0 U. | |

TPRC



THERMAL LINEAR EXPANSION -- ZIRCONIUM + URANIUM